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JAMES H. McGRAW, *President*
E. J. MEHREN, *Vice-President*

WILLARD CHEVALIER
General Manager
F. E. SCHMITT
Managing Editor

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The Engineering Year In Review and Prospect

An Editorial Survey

IN THIS ISSUE there is presented a review of the year just closed, as seen from the vantage point of engineering thought. It comprises an editorial survey of developments in the different fields of professional activity, notes and views of large projects, and a summary of the essential statistics of construction. These have been prepared by the editors to assist the reader in his own retrospect and forecast. In order that the inspiration of professional thought might not be lacking, there are included four articles by prominent engineers presenting studies of broad questions that have special importance in relation to the day's work. One of the major movements of the day, the intense activity in constructing large bridges for the service of transportation on the modern highway, is discussed by the dean of American bridge builders, Gustav Lindenthal. Prof. Raymond Olney outlines what the engineer has done to smooth man's path in the world's basic production activity, agriculture; he points out how scientific application of machine power is furthering the work of transforming the farmer from peasant to industrialist. A related process of mechanization is discussed by Charles H. Paul of the Arrowrock dam and the Miami conservancy enterprise, who deals with the operations of earth-moving. And, finally, since it is impossible to overlook the effect of the great Mississippi flood of last spring, W. W. DeBerard outlines its critical aspects, from the perspective derived from personal familiarity with the river and the advantages of a broad knowledge of engineering and public relations.

A Prosperous Year

WHATEVER the engineer's direct activity, he is affected vitally by the state of the business and political world. Looking out upon this broad landscape, he perceives favorable conditions. As to business, the civilized world is prosperous, the United States pre-eminently so; and politically that same world has been fairly well at rest, again the United States pre-eminently so. Probably both conditions may be traced back to the imperative need for production. After years spent in crude patching of economic and political structures, a relative confidence in the stability of political institutions supervened; hence, financial steadiness, witnessed at home by tremendous credit expansion and low discount rates, and abroad by currency reform or stabilization in a number of countries that still had haphazard money values. These matters favored large-scale expansion of production and consumption.

Remarkably enough, in Europe this improvement of favoring conditions, which to lesser degree existed during the two years preceding, made progress in spite of economic unbalance created by the non-selfcontained character of many of the countries and their continued isolation by customs obstacles or by absolute trade prohibitions. Evidently the pressure of demand and the necessities of trade at the moment were prevailing. An effort was made at an international economic congress last summer to remove the worst of such barriers, but, so far, with only paper results, except for the signing of a convention by a number of powers doing away with absolute prohibition of exports and imports.

Within the United States, in the absence of trade barriers the upbuilding forces of this late stage of the reconstruction epoch were able to work unhindered. They produced a year which the highest authorities have uniformly characterized as prosperous without precedent in all history, even against slightly greater business activity in some lines during 1926. And this prosperity as a whole was sound—a healthy development of industry and construction backed by a well regulated financial system and with such fairness in the distribution of production that labor troubles were almost non-existent. How great a surplus of productive energy the country possesses revealed itself in the fact that the destruction of several hundred million dollars of value by flood made not even a momentary impression on business or on market values.

Some Dark Spots

THERE have been some dark spots in the world prospect. Abroad these are chiefly political. In addition to the continued civil war in China and the isolation of Russia, several international rivalries loomed up sharply in Europe. Pre-war international diplomacy, far from being discredited, re-established itself further. The competitive attitude of governments came glaringly into view through the utter failure of attempts to discuss reduction of armament. Now that the United States is a creditor nation and has extensive business investment in Europe, the gloomy forebodings of those who see another war in the making are not wholly without meaning to us. On the business side, the reconstruction of England was slower than expected, the huge international debts owed to the United States are still in part unregulated, the reparations obligations are not fixed, and the relations between Germany and France are incompletely adjusted. But the business world developed an important counter-movement to political reaction, through the completion of several pan-European trade combines, designed to minimize international competition. However undesired this development may be from the American business view, it represents a potential agency of national stability.

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In the United States "profitless prosperity" has been pictured as a dark spot. Profit margins declined in many fields, and sellers often took business at a loss, in their drive for volume. Yet on the whole, business yielded excellent returns during the year. Keen competition is a natural result of our surplus of producing capacity. A more real cause for concern appeared in unfavorable conditions that developed in our financial system. A number of joint-stock land-bank failures occurred, though the system was thought to be absolutely secure. Coupled with the federal government's disavowal of its implied guarantee of their bonds, this event foreshadows the breakdown of the great agricultural land credit system established only a few years ago. While the semi-governmental federal land banks are more secure than the private joint-stock banks, they also have shown themselves to be not immune from trouble due to frozen assets. The federal reserve banking system also developed its first discord, when the central board insisted on dictating interest rates to the Chicago board and thereby undertook to control credit movement in a manner claimed to be disadvantageous to the West.

Domestic politics brought forth the significant news that President Coolidge would not take office for another term. Earlier in the year federal farm-aid legislation was vetoed, thereby strengthening the feeling in the agricultural areas that the nation's policies ignore the problems of the farmer. Thus, despite the momentary improvement in farm conditions by good crops and prices last fall, the political split between the farming and the manufacturing regions became deeper.

The Outlook

WITH production and consumption in their present adjustment, only favorable signs appear on the 1928 horizon. The political uncertainties of presidential year for once are faced with equanimity by the business world, as evidenced by the absence of market disturbance at the time of President Coolidge's "do not choose to run" dictum. Certainly no shrinkage of the domestic market is to be apprehended soon. Export trade perhaps ought to decrease as the inward pressure of exchange through debt payments comes to exceed the outward drift through loans abroad. Yet there is increasing confidence that a large export trade can be maintained, by virtue of our high efficiency of production. Numerous proofs of this efficiency have been broadcast during the year: our high per capita consumption of electric power, and high man-hour production rates. But imports of English woolens and German cameras, and export of American automobiles, suggest that individual factors are also involved, among them specialization in excellence. As most of our industries are making good progress along quality lines, this part of the reckoning appears to be most favorable.

As to construction: Investment of our surplus wealth in fixed works has grown to magnificent dimensions, and should continue in proportion to our production of wealth. Discussions of saturation and over-building have already been proven pointless by events, demonstrating that spare wealth will find a place for its safe storage. Building and public works both will prospectively not depart far from their existing rate. Construction needs are increased by the flood destruction in the Mississippi Valley and New England. And, beyond all, the rapid pace of modern progress is changing both city and country so thoroughly that new needs for elaborate public works develop faster than they have yet been met. Thus, the outlook for construction work in the civil engineer's own field of activity is promising.

Engineering and Construction

VIEWING the broad field of engineering and construction as a whole, 1927 stands out more in quantity figures than in tangible developments of method or type. While advance is to be found in almost every department, it is essentially in detail. Volumetrically the year's total of building and engineering construction attains the figure of $7,800,000,000. This is closely the same as the preceding year's total, and (in view of slight decrease in cost levels) indicates a greater volume total. Its significant feature is a gain in engineering and public-works operations, slightly overbalancing a drop in small and moderate-sized building. The signs point toward a maintained activity of about the same rate—minor changes are quite possible, but are not to be forecast from signs now apparent, all of which speak in general terms for stability of volume.

By reason of several large foreign contracts awarded to American firms during 1927, this class of work has attracted more than usual attention. A highway in Cuba, another in Colombia and a dam and highway in Abyssinia were each awarded for between $10,000,000 and $20,000,000. Smaller work, aggregating many millions more, is represented in highways, waterworks, sewerage systems, railways, buildings and port developments. While American organizations are most active in South America, they are also engaged in important construction in Greece, Poland, Africa, Japan, Cuba, Hawaii, Philippine Islands, Russia and the Dutch West Indies.

With extensive foreign-credit investments of American capital during the year it is natural that this extension of construction activities should follow. With respect to such operations the signs of the future are even harder to read than for domestic work; but it is plain that international relations of many kinds have a bearing on the outlook, and the same degree of stability as for work at home cannot safely be assigned to the foreign field.

Scientific Development

THOUGH without marked outward incident, scientific advance through research has continued to play a prominent part in American industrial progress during 1927. Study of problems of quality, production and service increased principally through trade associations, which represent the co-operation of different concerns within a single industry. One of the year's new happenings was the organization of a research department by the United States Steel Corporation, specifically directed to scientific research as distinguished from practical investigation of the kind that the company had previously carried on. By this innovation one of the oldest fundamental industries took a step toward placing itself on a level with those newer industries—the chemical, photographic, and automobile—which have depended essentially on research for leadership.

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Civil engineering in its narrower sense saw some encouraging items of progress in research work. Model investigation newly proved its merit in various applications, among them the study of building and bridge frames, skew arches, and dams. The successful duplication by model of the stress and deflection measurements on the Stevenson Creek arch dam was a notable achievement. A significant victory was won by the model idea when the Corps of Engineers approved the plan of building a laboratory to guide future river and harbor work. Bills now before Congress propose to establish such a laboratory in the Bureau of Standards or in the Geological Survey. On the other hand, the important subject of highway research, while it brought to light individual advances, saw a disappointing let-down in the functioning of the central correlating committee known as the Highway Research Board. The complexity of that organization seems to have resulted in ineffectiveness. But research will doubtless go on as before.

Bridge Construction

AS IN 1926, the bridge-building art has gone through a remarkable year; yet our comments on this page a year ago might be repeated almost verbatim. Large-size bridges are being built in unusual number. America and in minor measure the world are quite definitely in an era of large bridges, wholly because of highway traffic demands; only one railway bridge of large size is under construction at present, the Chesapeake & Ohio bridge at Cincinnati. It is worth note, however, that the largest existing swing span, 532 ft. long between pier centers and carrying two tracks, was put into operation by the Santa Fé during the year at its Fort Madison crossing of the Mississippi.

The outstanding development in the matter of exceptional structures was the final study and letting of contracts for the 3,500-ft. Hudson River suspension bridge at New York City, the Fort Lee bridge. One year ago the bonds for this public toll enterprise had been successfully marketed, but there was still divided opinion on important technical features of the plan. Subsequently, criticism, discussion and restudy confirmed the plan in general, and brought it with only minor modification to the point of letting contracts for the most difficult parts of the work, the west main piers and the entire superstructure. Both contracts produced surprises. The pier competition was won by an open cofferdam bid over pneumatic caissons, though the depth is 70 ft. or more to rock, through soft ground. By the end of the year the open method had demonstrated that it could meet the situation. This work gave new proof of the great resource of steel sheetpiling. In the matter of the superstructure, where wire and eyebar cables were in competition, the former brought the lowest bid and were adopted, though the difference was not large enough to be conclusive as between the two types of cable. As it is, however, the four 36-in. parallel-wire cables to be built under this contract will far outrank any cable work yet done.

Only second in importance to the inception of the Hudson River bridge was the beginning of work on the Detroit River bridge and on the Mount Hope bridge, both large suspension structures, and the completion of definite plans for a 1,600-ft. steel arch bridge to be built across the Kill van Kull at Bayonne—the latter, like the Hudson River bridge, being an undertaking of the Port of New York Authority. One other large suspension bridge is now under construction, the 1,500-ft. mid-Hudson bridge at Poughkeepsie. Thus, there is quite remarkable activity in the building of suspension bridges. A somewhat smaller bridge of this type over the Ohio River was completed during the year. A number of truss bridges over the Ohio, the St. Lawrence and the Mississippi further illustrate the magnitude of operations in the construction of major stream crossings.

Among large bridges completed during the year were the Carquinez, Antioch and Dumbarton bridges at San Francisco bay, the Peace bridge over the Niagara River, several Ohio River bridges, and the Lake Pontchartrain bridge, all of them private toll bridges except the Peace bridge, which is of semi-public character. There appears to be quite as much interest in toll bridges in financial circles as in the two previous years, though fewer new toll projects were initiated. Some tendencies to check the orgy of toll-bridge finance also appeared. The state of Washington announced a policy opposed to highway toll bridges, for the present will regulate such tolls, and is moving toward the ultimate elimination from state highways of all toll bridges.

In the matter of the great trans-bay bridge at San Francisco, two interesting steps were taken during 1927. San Francisco engaged a board of engineers to report on the best site and type for a bridge, which board reported in favor of a location with western terminus on Rincon Hill, San Francisco. Later, the authorities made application to the War Department for approval of a bridge on this location, but the War Department, at the instance of the Navy authorities, rejected the application. It is now proposed by San Francisco to get direct authorization from Congress for a bridge at this point. The case is a new instance of the modern tendency to question the wisdom of army engineer control over navigable waters.

Building Progress

IN THE effervescence of structural building activity during 1927, the tall building rose to a still more prominent place in the sun. The aggregate activity in such structures was large, and average building heights are increasing, though extreme records are not being broken. Chicago with its 521-ft. Mather Tower building contributed a striking example of height. Consideration of tall building design emerged from its resting place in the minds of individuals and became a subject for debate in the technical societies, ranging from wind stresses and methods for analyzing windbracing to the social problem of the effect of tall buildings on urban congestion and the economic problem of rental return as affected by building height.

Reverberations occurred from the earthquake experiences of the past few years in the form of revived interest, especially on the Pacific Coast, in earthquake-resistant construction. Most significant was a building survey made by fire underwriters on the Pacific Coast to determine whether their rates were not too low in comparison with the earthquake risk involved in the ordinary structure. The outstanding example of earthquake-resistant design occurred in an American designed and

constructed bank building in Tokyo, Japan, using special columns with their heaviest section at girder connections to take the bending moments induced by an earthquake thrust of one-tenth gravity.

Construction Technique

SYSTEMATIC planning of construction, with co-ordinate mechanization of processes, has attained higher standards. This is not the creation of a year but the continuation of an evolution, which has been going on rapidly throughout a decade of years, and is exemplified by a number of notable operations which have been in progress during the year. Today development has reached a stage where not only large operations are planned and equipped with engineering skill, but small work is highly mechanized and is scheduled with exactness. The proofs of these assertions lie in the construction operations which are going on where modern engineering structures are being built. Some of the German, French and other foreign construction operations, which have been recorded during the year in this journal and in European technical publications, are as fully planned in advance, as precisely scheduled in time and sequence and as completely mechanized as any which have been undertaken on this side of the ocean. And these latter operations, as there has been occasion to exemplify many times in these pages for the year just gone, exhibit a high quality of engineering reasoning and exactitude of formal plans and instructions. The situation which has been reached in the highest examples of construction planning, in the sense of scheduling operations and selecting and co-ordinating mechanical plant, is calling for construction-plant engineering service of a special character. As a result construction plants are beginning to be designed as co-ordinate units, and not brought together as assemblages of machinery. The good examples are, however, still isolated; the practice of plant designing is not general, it is not an inherent part of engineering consciousness as is designing of structure. Here is the task for the future.

Materials of Construction

IN THE field of materials, 1927 saw hardly more than routine developments. Even the great Hudson River suspension bridge, whose exceptionally severe demands would tend to bring forth improved grades of material, will be built of carbon steel, silicon steel and nickel steel closely conforming to normal specifications, with slight advance in wire strength.

Cement is in a more interesting state. Standard portland cement was slightly increased in its specification minima during the previous year, in conformity to the pressure of demand for higher strength. During 1927 users continued to show a growing demand for high strength, and particularly high early strength. A number of cements to meet this demand are on the market; one or two new ones were added during the year. At the moment, the trend seems to be toward the commercial establishment of one or more special grades with higher properties than standard portland, and, of course, higher price. Road repair, pavement reconstruction in busy streets, and similar services make the advantage of early high strength appear very attractive. At the same time, the cement industry is specially interesting because, after a number of years of rapid expansion of yearly consumption, the rate of increase is now distinctly slower. The marked excess in producing capacity thus becomes a factor of possible influence on the developments of the immediate future, both technical and commercial.

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Concrete

ADVANCE in the concrete art during the past year lay in fuller consideration of aggregate and water and extension of field control. No new method of design has supplanted the practical theory enunciated by Abrams almost ten years ago, but practical workers as well as researchers in concrete are supplementing the water-cement strength relation with fuller studies of aggregate for ease of placement, economy, uniformity and tightness. Shape, size, kind, quality and grading of the aggregate are being studied.

The excellence of concrete making in average every-day performance has improved noticeably during the year. Studied proportioning has at last entered the concrete road field, having been accepted a few months ago as a basic procedure by a committee of the Highway Research Board. Transverse testing of concrete in road work gained in extent of use, though at the same time it has drawn attention to the fact that concrete giving a high beam test is not necessarily best in quality, particularly so far as wear resistance and impermeability are concerned.

Railroad Operation

RAILROAD earnings and traffic both declined somewhat during the past year in comparison with 1926, but there was no falling off in operating efficiency. Consequently, the year has been a satisfactory one. New records for such important factors as average load per train and car-miles per day were established. They were brought about, in large part, through the expenditure of considerable sums of money during the past eight years for new cars and locomotives, for line improvements and better terminal facilities. Expenditures for such purposes during the past year amounted to $750,000,000 as compared with $875,000,000 for 1926.

Little has been done during the year toward further railroad consolidations. The Interstate Commerce Commission again has recommended to Congress that it be relieved of the necessity of preparing a complete plan for the consolidation of all the railroads into a few large systems, due to the practical impossibility of its ever being able to put such a plan into effect without the consent of the railroads. Meanwhile the presidents of the Eastern railroads continue their discussions looking toward the formation of four or five major systems in the eastern part of the country. Pending the outcome of these discussions, as well as action by Congress in the matter of railroad consolidation, the Interstate Commerce Commission has declined to authorize any important railroad consolidation.

Valuation continues to be as much of a muddle as ever, a continuing source of expense to the country as well as to the railroads, with little yet to indicate whether or not the millions of dollars put into the work have been spent to any useful purpose. The test case (St. Louis

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& O'Fallon Railway Company vs. the United States of America) now being fought in the courts to determine whether the methods followed by the Interstate Commerce Commission in fixing values upon the railroads are constitutional, is proceeding toward the Supreme Court.

Motor-bus transportation took a larger part in passenger movements, and found its place in the general system more definitely. The present magnitude of the bus transportation industry may be expressed by the figure of 90,000 buses now in commercial operation. This is more than twice the rolling stock of five years ago.

Railroad Engineering

CONSTRUCTION and planning of railroad extensions has been active during 1927, including further progress on the several development lines in the Southwest. In the central states the most notable piece of construction is the new line of the Chesapeake & Ohio system, the Chesapeake & Hocking, by which the C. & O. gains access to the Lakes at Toledo over its own low-grade lines. Another step in the interconnection of allied lines is the approval and putting under contract of a short but difficult mountain link in Kentucky to connect the Louisville & Nashville with the Seaboard Air Line. The six-mile Moffat Tunnel has been completed. Plans for utilizing it as part of a new route to the Pacific Coast have not yet come to fruition. On the other hand the eight-mile Cascade Tunnel, whose construction is progressing rapidly, will at once materially improve operating conditions on the Great Northern Railway.

Large passenger station projects continue to hold an important place in railroad improvement programs. At the close of the year there was some revival of activity at Chicago for a fourth great union station, which project has hung fire for some years because the four groups of railroads concerned cannot agree upon any one of the several possible sites or plans. Work on the new suburban terminal of the Illinois Central Railroad at Chicago has stopped. At Cincinnati, the much needed union station is assured through the organization of a company which represents the several railroads and the city in the making of plans to that end. Buffalo at last has its new station under way; Boston is to see the reconstruction of North Station on a grand scale, and work is progressing on the new union station at Cleveland and on the new Pennsylvania Railroad terminal at Philadelphia. In the latter city, plans for new stations for both the Reading and Baltimore & Ohio are progressing.

Electric operation of Chicago suburban service on the Illinois Central Railroad was begun in August. At Philadelphia, the Pennsylvania Railroad has about completed the electrification of its line to Wilmington, Del., and plans for the electrification of part of the Reading suburban lines have been announced. Electrification of the Boston, Revere Beach & Lynn Railroad, a narrow-gage suburban line 15 miles long, has also been proposed.

In track work, twelve months' service of the ¼-mile concrete roadbed on the Pere Marquette Railroad is said to show satisfactory results. Tests of concrete ties are being made by the Pennsylvania, and the Delaware & Hudson is continuing its experiments with ties made of old steel rails.

The work of installing automatic train control on most of the major railroad systems has made good progress during the year.

Highway Progress

HIGHWAY progress in 1927 has been chiefly marked by increasing development of intermediate-type roads. In all but a few states and particularly in the states of the Middle and Far West and in the Southern states, with growing traffic and limited road funds in proportion to highway mileages, there is a call for roads occupying a position between the traffic-bound and the hard-surfaced types, and this call is being answered by trying many expedients in surface bonding and true surfacing by tar and asphaltic oils. The results obtained have been widely encouraging and are leading to practice and service surveys and to extended materials research. In hard roads progress has continued along the ways of the last few years toward increased use of the thickened-edge design with a longitudinal joint or plane of weakness separating traffic lanes. Subgrade studies are beginning to reach beyond the research laboratory into the practice of the construction engineer. As yet the development is tentative and of interest mostly as an indication. The mileage of highway under engineering maintenance is increasing; route marking is becoming more uniform and consistent. A great increase has been made in the mileage kept open by snow removal in winter for year-around service. There is now in the most progressive roadbuilding states no such condition, as far at least as state-system roads go, as seasonal limitation of traffic by roadway conditions. The mileages of road paved, or otherwise surfaced and graded to engineering standards, have increased a little over previous years. The expenditures for all road improvement in 1927 are estimated at a billion and one-third dollars. This is somewhat more than was spent the year previous. These are evidences of a stable growing business and this is the stature to which highway improvement has been growing since federal-aid legislation in 1916 set up the present systems of administration of public roads.

Waterways

THE major waterway projects which are actually under construction have made fair progress during the year. On the Atlantic seaboard, the work of changing the Chesapeake and Delaware Canal to a sea-level route was completed and the canal was opened to traffic early in the spring. Along the Ohio River, work on the fixed and movable dams for improving the navagability of that stream is well along toward completion. That on the upper Mississippi system is progressing and cities along the route are constructing port facilities for the interchange of traffic with the barge lines on the river.

Little real progress has been made on the proposed new St. Lawrence waterway. The joint board of engineers appointed by the two governments in 1924 to study the project submitted a favorable report upon it just before the close of 1926, but the whole subject is too much mixed up in both national and international politics to hold any prospect of immediate action looking toward actual construction. In this country, the New York Barge Canal enthusiasts and the advocates of the "All-American Canal" are opposing it, painting a

very black picture of the international complications involved, while in Canada powerful Montreal interests are opposing construction of the enlarged canal on the same grounds, apparently fearing that Montreal will lose its supremacy as a grain port if the work is carried out. Since the engineers' report was submitted the United States government has made some advances to the Canadian government looking toward the start of negotiations, but so far the latter government has not seen its way clear to act. The large amount of power possible of development as an adjunct of the navigation project adds a vital complication.

Aerial Navigation

IN THE history of aërial navigation the year 1927 will be longest remembered for its many demonstrations of the capabilities of aircraft. Led by the incomparable Lindbergh, who, by a unique combination of ability, courage and personality has made the entire nation air-conscious, American aviators have within the year crossed the Atlantic, most of the Pacific, and flown nearly around the world. An aërial lecture tour by Colonel Lindbergh reaching every one of the 48 states furthered interest in municipal airports, which presages an increase in their construction during 1928. An air race across the continent attracted more civilian planes than were registered in the entire country in 1917. Despite these remarkable demonstrations of an increase in the use and performance of aircraft, the year has not been without its tragedies, about twenty of our outstanding aviators having been lost in the ocean flights.

Last year in this space it was said that "Some years hence the past year (1926) may be looked upon as the real starting point of airway transportation." Developments in 1927 support the prediction. The effects of the Air Commerce Act and the Daniel Guggenheim Fund for the Promotion of Aeronautics, both established in 1926, began to be felt in 1927. Municipal airport development has surpassed expectations and the government airway lighting program has been completed on 5,000 miles of routes; 3,400 miles additional are planned to be lighted during the first six months of 1928. On July 1, 1927, the air mail service officially passed from governmental control into the hands of private companies under contract with the post office department. All this progress in aviation is being achieved wholly without government subsidy.

The Struggle for Water

THE world-old struggle for possession and protection of sources of water supply increases in more than direct ratio to population growth, because of growing pollution on the one hand and on the other through an ever greater demand for water both safe and pleasant in character. Municipalities, industrial and hydro-electric companies and in some cases irrigation, commerce and navigation interests are engaged in the struggle, which has taken on interstate proportions as to the Connecticut, Delaware and Colorado Rivers and both interstate and international in respect to the Great Lakes, the St. Lawrence and Mississippi. In New England, Connecticut represented to Massachusetts the likelihood of legal action to prevent the Boston Metropolitan District from diverting for its use water which naturally flow into the Connecticut River, while the U. S. War Department served notice on the Boston Metropolitan District that it must apply for a permit before diverting water from the Connecticut—something apparently quite new on the part of the War Department as regards controlling the municipal use of water.

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Interstate water pollution by sewage is fairly well in hand in many of our states, but there is scarcely a shadow of control of interstate pollution by the federal government and only the crudest beginning, in most states, of any legal control whatever of pollution by industrial wastes. Notwithstanding these drawbacks notable progress has been made in the control of the pollution of the waters of one of the largest and most densely populated drainage areas, the Ohio River, through a confederation of state health authorities, while in that and other regions control of pollution by industrial wastes is making progress through the co-operation of state health authorities with the paper and pulp, canning, leather and phenol-producing industries.

Sewage and Refuse

COMPARED with what may be expected in the next decade or two, only a beginning has been made in the construction of works for the disposal of municipal sewage, garbage and miscellaneous dry wastes. With some notable exceptions, the management of existing sewage-works and garbage disposal plants is woefully deficient, but advance is being made in this respect with the growing recognition of the importance of putting technically trained men in charge of operation.

In sewage treatment, the activated-sludge process, introduced ten years ago, is making slow but sure progress in the United States, Canada, England and India. Milwaukee, Indianapolis and Chicago are the only large cities that have adopted the process, but it is included in a project of considerable size now in the design stage for a part of New York City. In America activation is most generally effected by means of compressed air but of late a fair percentage of small installations have included mechanical agitation of one of the two types that are rivaling air agitation in England. Chlorination of sewage is making notable progress, as witnessed by many recent articles dealing with working-scale studies. Among the few cities that are building plants for the disposal of garbage and rubbish, the trend is towards incineration, excluding garbage in most of the larger cities, and with salvaging of commercial products by sorting on conveyor belts, so only the tailings go to the furnaces—as at Baltimore and Los Angeles.

Engineer Licensing

LICENSING has added no new state to the list of 22 in which some sort of registration is required for the practice of engineering. The 1927 sessions of the National Council of State Boards of Engineering Examiners adopted the model registration law suggested by the American Society of Civil Engineers but otherwise were meager in accomplishments. The advantages or disadvantages of licensing still remain strongly controversial matters in professional circles. It is significant that the attorney general of the state of New York is to proceed legally against delinquents, though the New

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York law is now almost five years old, having gone into effect May 5, 1923. The attorney general's office explains that this period has been allowed so that engineers might acquaint themselves with the law's operation. Engineers in states which as yet have not adopted license laws ask, "Are there any quacks in the profession?" and if so "has licensing excluded them?"

Rapid Transit

LITTLE developed in urban rapid transit during 1927, apart from continuation of work on the new subway systems of New York and Philadelphia. Some $50,000,000 worth of new contracts was let during the year in the New York system, and about half that amount for the Philadelphia system. In both cities, the question of operating plans for the new lines was much under discussion, but did not reach even tentative solution. The New York system is still most likely to be operated as a municipal line, independent of the two present company-operated systems. However, the efficiency of company operation was subjected to sharp question, and some plans have been proposed for city purchase of the company lines. Other cities with their growth of population and congestion are moving steadily toward the inevitable beginning of rapid transit construction, but no tangible developments during the year are to be recorded.

Traffic Relief and Control

TRAFFIC relief and traffic control have been materially furthered during 1927 if in no other way than that there is a definite trend toward the engineering profession for solution.

Many cities have had traffic reports by engineers. The Chicago report, one of the most comprehensive, is being gradually put into application, especially the recommendation to prohibit parking in the Loop district, which went into effect with 1928. In Chicago, also, the installation of stop-and-go lights has not been haphazard or dictated by politicians or influential citizens, but has been based on traffic counts. In addition administration was put under control of a metropolitan advisory board including officials from all of the various municipalities and park boards, and in the city itself under a division of street traffic engineering in the Department of Public Works. Throughout the country the unrestricted installation of stop-and-go signals in small towns especially has caused a decided slowing up of traffic. Thousands of such lights cannot be justified from the traffic standpoint; nor are they operated with intelligence.

Other important factors in traffic handling are claiming much attention. Lack of terminal facilities in the way of garage or parking facilities for street traffic is one of the major problems of congestion. Competitive use of streets by different types of traffic is another. In some cities street-car mileage has been reduced, in others the terminal parking of buses has been restricted. Many others have established extensive one-way-street regulations, and some are marking center lines or even traffic lanes. Pedestrain control at crossings is another troublesome element. In Los Angeles pedestrians have been taught to follow the lights and bells. In Chicago downtown pedestrian traffic could not be accommodated unless red signals were generally disregarded. In San Francisco, where diagonal intersections complicate the case, pedestrian control went into effect Nov. 15 and has been eminently successful.

A decided trend has set in toward by-passing trunk line traffic around business districts, to the benefit of both. The best example is in the routing of the 200-ft. three-state boulevard, 165 miles long from Milwaukee around Chicago to Michigan City.

Street widening for traffic relief is engaging stupendous sums. Practically every city of 100,000 or more population has projects in contemplation or under way. The very largest cities may find increased street capacity in doubledecking, but the great majority of American cities will long find it more economical to push back property lines, move back structures or cut them off. Similarly a pressing demand for wider highways is developing, even aside from that for the few so-called super-highways.

Power Development

WITH one exception, nothing spectacular occurred in the field of hydro-electric power development during the year 1927. Construction of a number of new plants was begun and work on large plants which was started before the year opened progressed rapidly. Accordingly the total horsepower in hydro-electric plants which will be put into service in 1928 will be large. Nevertheless, the development of water power is slowing up, partly because power sites which can be developed cheaply are more and more difficult to find, but more especially on account of the advances which have been made in the steam-power field.

The one unusual item in the hydro-electric power field is the Rocky River plant in Connecticut where large electrically-driven pumps are being installed to use off-peak power to pump water into a high-level storage reservoir. This practice is common in Europe but this is the first time it has been tried on a large scale in this country.

Developments in equipment for automatic and remote-control stations have favored the development of remote water power sites. Another factor which is sure to work to the advantage of water power is the progress that is being made in high-tension transmission. Already there are half a dozen long-distance transmission lines that either are operating or are designed for ultimate operation at 220,000 volts.

Improvements in waterwheel design have been chiefly in the form of refinements giving safer and more accurate control and greater efficiencies. An efficiency record for reaction turbines was established at the Melones plant, put in service during the year, where efficiencies of 94 per cent over a considerable range of head were developed.

The second banded penstock of foreign manufacture has been installed on the west coast this year in the Bucks Creek plant, a plant that holds the high-head record for the United States with a static head of 2,561 ft.

On the financial side of power development, steam as well as water, 1928 is likely to see a slowing up of new construction until the bankers know what Congress is going to do to the power companies. Just now there is every indication that it will stage a big investigation of the whole system of financing power companies and holding companies.

Advances in the field of steam power development which have had such a marked effect on the water power situation are chiefly in the use of large-size power generating units, refinements in turbine and boiler design which have cut down maintenance expenses, and an increasing use of pulverized coal for fuel. Interconnection of power systems has had much to do with this change, also, as it has made possible the use of larger generating units with a decrease in cost per kilowatt of installed capacity.

The Contracting Business

WITH seven billion dollars for construction, contractors have been busy. Yet contracting has been no more—and no less—a profitable business than it has always been. It is still handicapped by an irresponsible element in the business, by bad surety bonding conditions, by the competition of municipal day labor, by vicious lien laws, by poor estimating, erratic bidding and incompetent practitioners. The struggle against the intrenched material dealers interests for a lien law reasonably fair to the owner and the builder has been continued almost hopelessly. Similarly the fight for improved surety bonding practice has achieved only slight success. There has been progress in safety work and notable advance in quantity surveying practice, mainly through contractors' group action. Membership and geographical representation have increased in the national organization. The Associated General Contractors now has over a hundred chapters, many of which are handling with intelligence and vision the construction business problems of their localities. Though the year's changes in the contracting business have been small, they have been toward improvement.

Labor Relations

THOUGH some strikes marked the general industrial field during the past year, the construction industry has been virtually free of them. A big building year, little unemployment, a slight general increase in wages and some recession in the cost of living made 1927 a prosperous one for the construction industry. Absence of strikes is, as in previous years, in some measure traceable to the existence of the National Board of Jurisdictional Awards in the construction industry. The strength lying behind the proceedings of that award board was the constitutional requirement that, pending decisions from the board, work should continue. As there was no appeal from the board's decision, this meant continuous work. Unhappily, however, late in the year the American Federation of Labor's building trades department, including the very large proportion of building trades mechanics, which organization had three members on the award board, withdrew from that board, necessitating its dissolution. With the increasing mechanization of construction and the introduction of substitute materials, there is almost daily necessity for the settling of jurisdictional disputes arising out of the question, "Who is to place these new materials?" It is conceivable that provision within the union may be made for settling these disputes, but unless the same guarantee of continuous work pending decisions is given, there must result loss of time and unsound competition; and these things make for economic and financial loss for the contractor, the building mechanic and the general public.

The Engineering Year

The Standards Movement

MUCH activity without many tangible results characterized the standards movement during the year. There have been strong efforts for some years to draw American industry into fuller participation in the making and adopting of centralized standards. So far, however, the larger part of industry has not taken up the idea aggressively enough. While the evolution of production and distribution makes reasonable standardization a more apparent necessity each year, industry in the main has failed to observe this and has continued to work through spontaneous commercial evolution of prevailing types and dimensions, or else small group action. To draw these circles into active co-operation with the American Engineering Standards Committee, the latter organization devoted much of 1927 to study of plans for reconstituting itself as a more direct agency of industry. In the meantime the government undertook to enter the standards field in a leading way, by expanding the Commercial Standards division of the Department of Commerce and integrating it with the Bureau of Standards. It is hard to forecast the future of this unusual governmental step. For the moment it tends to confuse the growth of standards activities. In a broader field, efforts begun in 1926 to promote international co-operation in standards work—on a rather undefined basis and without present industrial need for such functioning—made but little progress within the past year.

Equipment and Materials

NEW developments in the field of equipment and materials were recorded in no more than normal amount during 1927, yet tendencies which became apparent in several directions promise important results. Among the changes are growth in use of ready-mixed concrete, increased utilization of welded machine parts, extension of the crawler tread to trailers, wagons and motor trucks, application of Diesel engines to industrial locomotives and tractors; and new and larger belt conveyor installations to handle wet concrete and earth as well as aggregates and cement.

Motor truck manufacturers have taken cognizance of the highway contractor's needs to an unprecedented degree, with the result that many new trucks and truck bodies have been designed specifically for highway work. Snow removal requirements brought out a new blower-type snow plow. Other developments included increased use of oil-burning salamanders, the introduction of a small steam turbine electric generator, and special attention by motor manufacturers to dust-tight motor housing.

In the field of materials, the 2¼x4x8½-in. plain wire-cut paving brick was reinstated, making a total of five recognized varieties. This is the first time that a paving brick size has been added, all previous action involving elimination from the original 55 varieties in 1921. A patented asphalt pavement providing, by means of special machinery, an interlock between the base and wearing surface was introduced. Cement activity was represented by the introduction of a new rapid-hardening product being a finely ground portland, the licensing of a number of American manufacturers to make a cement

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admixed with chemically treated gypsum and tannin, and a notable increase in the use of alumina cement. The increased use of paper bags for cement noted since 1923 continued. Other developments in the field of materials included the establishment of a research laboratory for crushed stone and the adoption of a single grade (intermediate A.S.T.M.) of billet stock for reinforcing steel.

Structural Welding

THOUGH any one year's contribution to structural engineering growth is not easy to appraise, there are evidences of vigorous progress which indicate a virile substratum of engineering thought and initiative. Such was the activity in structural welding. It was marked by the construction of a number of industrial buildings, the largest a 2-acre factory at Derry, Pa., completed late in the year. Another all-welded manufacturing building is now under construction in Philadelphia. Welding was promoted not only on the practical but also on the technological side, the latter largely through the influence of a research committee of the American Welding Society, whose final results are expected to give tangible data for structural design. Some important welded bridgework was also undertaken, including the reinforcement of a railway bridge across the Missouri at Leavenworth, the addition of a second deck to the Susquehanna River highway bridge at Havre de Grace, and the construction of a skew railway truss bridge at Chicopee Falls. Somewhat related is the extending use of welded structural assemblages in place of heavy castings in machinery, on power shovels, trailers, engine and pump bases, and the frames of electric machines. Further, welded-joint pipe-line construction gained largely in use.

Great Disasters

NINETEEN twenty-seven was a remarkable year for great natural disasters claiming the attention of the engineer. In them he found a need for quickened study as a means of coping with repetitions of them. Foremost were the spring flood in the Mississippi and the fall flood in New England. Floods in Europe, storms on the West Coast, torrential rainfall over a widespread area and earthquakes of wide distribution and varied intensity have more than ever made the layman conscious of his need for engineering counsel and assistance. The Mississippi finds comment elsewhere. The New England flood of November put into bold relief the fact that flood control, theretofore more or less centered on rivers of flat gradient, must equally concern itself with flashy streams fed from small watersheds, whose topography means high runoff rates. These two floods far more than earlier ones make mandatory the establishment of proper agencies for laboratory studies in this large and involved field of hydraulics.

Land Development

FOR many years federal arid-land reclamation has been the most conspicuous element of our areal expansion. A year ago this appeared to be at its end, in view of the demonstrated impossibility of obtaining repayment in all but exceptional cases. Yet during the year this development was resumed. Two projects in Eastern Oregon are under construction or in preparation therefor, together with the Echo reservoir project for supplementary water supply to Utah areas. All will be creditable from an engineering standpoint, but the Oregon projects at least have a different aspect on the business side, since the irrigation works are so costly that repayment by the landholders seems quite unlikely. In the meantime the existing projects have not discontinued their practice of asking the government to postpone their payments, despite the wholesale write-off of twenty-five or thirty million dollars by Congress two years ago, which was expected to end further complaints or demands for charity.

Study of Southern reclamation began before 1927. During the year half a dozen tracts in the Southeastern states were examined for suitability for colonization. No further progress in the matter has been made, as Southern interests appear to be waiting for a federal appropriation to pay for the colonization development. In another part of the country a movement has been organized to ask free-interest federal money for swamp drainage on a long-time repayment plan. Thus, the example of the arid-land irrigationists in drawing public funds for private land development is leading others to cast expectant eyes on the federal treasury.

Colorado River Control

IN THE great question of controlling the Colorado, the close of the 1927 session of Congress saw the death of the Boulder Canyon Bill in a bitter filibuster. While it enlisted wide support, yet it was opposed by Arizona, which would have obtained but little water and could not obtain sanction to the power royalties which it was willing to take in place of water; it was also opposed by private power interests, who held that the bill would put the government into the power business, and by some of the up-river states, who thought the bill would jeopardize the long-time pre-emption of unused water which they had sought to secure through the Colorado River Compact. The situation was particularly stirring because the delta had been getting into steadily more hazardous condition, and because of heavy snowfalls in the mountains and consequent danger of a great flood. Fortunately, the flood was forestalled by gradual melting of the snow, so that the spring high water was even below average. But the safety of the delta has not improved, and any year is flood year. The reasons for action on a Colorado River control project are therefore more urgent each year. No new control scheme has been advanced, but the Boulder Canyon Bill has again been introduced in the new session of Congress. Interstate antagonisms persist, however. The basin states have made no progress toward agreeing on a Colorado River compact, despite a protracted series of conferences held last fall. On the contrary, these conferences appear to place a greater obstacle in the way of any federal or federal-aid plan for the Colorado, by showing virtual unanimity among the states on their claim to ownership of the potential power of the river, and their right to tax either property or the power which may be produced.

Engineering in Agriculture

A Sketch of the Great Agricultural Revolution Wrought by Farm Machinery, and the Present Transformation Which Power Is Bringing About, Together With a Forecast of Problems to Be Solved by Agricultural Engineers in the Future

By RAYMOND OLNEY

Secretary of the American Society of Agricultural Engineers
St. Joseph, Mich.

WHAT can the engineer do for agriculture? The answer to this question is simple. He can do anything for agriculture that he has already done or can do for transportation, manufacturing, mining or any other field to which he has applied his knowledge and skill.

There is a very definite and a very important relationship between engineering and agriculture. Every industry has its engineering relationships. Agriculture, like manufacturing, is concerned with the production and distribution of its products. And since engineering deals with labor, power and materials, it has much to do with agricultural production. Engineering is likewise related to the distribution of agricultural products in providing for transportation and storage facilities, processing plants and in other ways.

Although conditions and requirements in manufacturing may be radically different from those in agriculture, the fundamental need and the problem of applying engineering to the latter are essentially the same as in the former. Engineering is sure to have as extensive application in agriculture as it has had in other industries, and with equally far-reaching results. History shows that it has already exerted a marked influence on the development of agriculture.

The Age of Hand Tools—Up to the time of the Civil War very little progress had been made in the development of labor-saving farm implements. At that time the wooden plow, harrow, hoe, rake, fork, scythe, flail, wagon and cart were in use—largely hand tools. In the same period the population was practically all on farms. Census reports show that in 1800 some 97 per cent of the country's population was agricultural, and even in 1850 the figure was still 90 per cent.

Following the close of the Civil War important developments took place. The vast, fertile prairie lands of the Mississippi Valley were taken up. The steel plow and the grain reaper, introduced shortly before, became common, and soon came self-binder, grain drill, corn planter and threshing machine. So great was the increase in the productive capacity of the man on the farm that overproduction resulted.

Machine Farming—The year 1850 marks the close of hand-method production in American agriculture. In the 75 years from 1850 to 1925 tremendous changes have taken place in American agriculture. The percentage of the country's population on the farm has decreased 90 per cent to 25 per cent; extensive use of labor-saving machinery has made it possible to release large numbers of workers from agriculture. As a result of better machines the production per worker has increased and the cost has decreased. Whereas it previously required more than three hours to produce a bushel of wheat, it now requires only a few minutes.

American farmers are the most efficient in the world mainly because they use more machinery and other engineering applications than do farmers of other countries. Giving due credit to management and finance, it is true that America's pre-eminence in agriculture, as it is in manufacturing, is an engineering pre-eminence.

Only within the past two decades has it been recognized that a definite relationship exists between engineering and agriculture. This has come about coincidentally with the introduction of mechanical power into farming

A HIGH TYPE OF AGRICULTURAL MACHINE DEVELOPMENT

operations. Up to fifteen years ago mechanical power applications in agriculture were practically limited to the use of the steam traction engine in threshing and for operating other heavy belt-driven machinery, and also in large plowing outfits, especially in the prairie sections of the Northwest. With the introduction of the internal-combustion-engine tractor, tremendous impetus was given to the application of mechanical power to farming, particularly since the close of the World War. It has been adapted to a great variety of farming operations, until today there are a number of farms—even where diversified agriculture is practiced—on which no animal power whatever is used.

Mechanical Power—Some idea of the possibilities of engineering in agriculture may be had by consideration of the power requirements. Studies by the federal Department of Agriculture show that the total amount of power used annually on farms in the United States amounts to close to 16 billion horsepower-hours. The average power utilized per year per agricultural worker amounts to about 1,500 hp.-hr. Mechanical power, along with labor-saving machinery, is an important factor in lowering production expense, undoubtedly the biggest problem facing the farmer today.

Power and labor constitute from 40 to 85 per cent of farm production costs. In manufacturing, power and labor costs have been reduced by mechanical power and labor-saving machinery. The same result is being obtained in agriculture. For example, G. W. McCuen at Ohio State University has demonstrated that complete motorization of the corn crop is practical and economical. In experiments extending over a period of four years he has reduced the time necessary to grow and harvest an acre of corn from 26 to 5.77 man-hours. A man with a tractor and three-bottom plow can plow eight to twelve acres a day, but with horses and a walking plow two acres would be a big day's work.

FARM TRANSPORTATION REVOLUTIONIZED BY THE MOTOR TRUCK

Frank I. Mann, one of America's foremost farmers, once said: "Timeliness is the essence of good farming." By means of mechanical power the farmer is enabled to take advantage of this factor of timeliness. As a general thing, farmers cannot afford to keep enough horses to supply the peak load of power needed in rush seasons. It is highly important that favorable soil and weather conditions for putting in or taking off a crop be taken advantage of. The period of ideal conditions usually is of short duration. With a tractor and a double shift of operators the farmer is enabled to carry on certain operations 24 hours a day.

New Power Machines—Not only has mechanical power, and more especially the tractor, been a big factor in extending the use of both field and belt-driven machinery in recent years, but it has influenced a number of important changes in farm machinery. For example, the combined grain harvester-thresher, generally known as the "combine," has been used for many years in the Pacific Northwest. In the past few years it has been introduced east of the Rocky Mountains, in the wheat-growing sections of the Great Plains area, and now it is spreading rapidly in the territory east of the Mississippi River. The introduction of this machine, which, incidentally, cuts 20c. a bushel from the cost of producing wheat, could not have been nearly so rapid without the tractor.

The tractor has made it possible to combine the use of such implements as the gang plow, disk harrow, smoothing harrow, soil packer and grain drill, which is a decided advantage in putting in a crop under favorable soil conditions. The disk harrow, one of the most valuable of farm implements in the preparation of the seedbed, is literally a horse-killer, but its use has rapidly increased with the coming of the tractor, because of the greater power available for its more effective use. Tractors of the general-purpose type—that is, especially designed for cultivating row crops—have not only extended power to planting, cultivating and harvesting of row crops but have increased the size of these machines from one-row to three- and four-row capacity, especially for the planting and cultivating operations.

The combine idea as applied to grain harvesting and threshing is of such tremendous importance from the standpoint of reducing production costs that engineers directly concerned with the problems of agricultural production are studying intensely the application of this idea to other crops. A combine adapted to corn harvesting is now in process of development. Combining the operations of digging, elevating, sacking and even loading potatoes has been made practical.

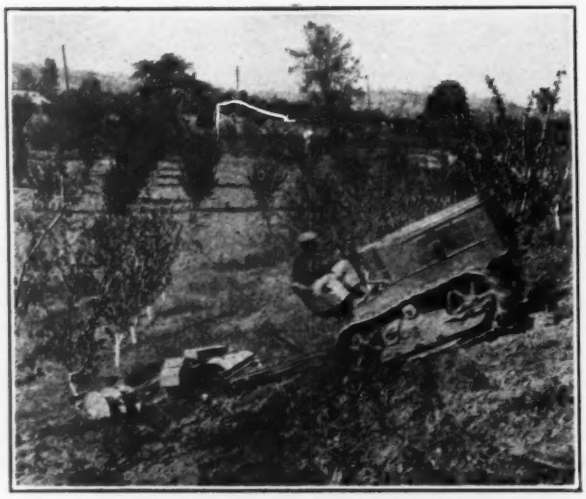
Extended Power Use—The development of mechanical driers gives great promise in the direction of completely mechanizing the operations of cutting and curing alfalfa and other hay crops. The harvesting of the cotton crop, for which the South has been dependent practically entirely on negro labor, has until recently failed of efforts to make it a machine operation. However, the development of strippers and pickers within the past few years indicates that the practically complete and economical mechanization of that crop will soon be realized.

But even aside from field or tractive uses the farm tractor is used extensively as a stationary power unit for driving ensilage cutters, feed grinders, corn husker-shredders, hay balers, buzz saws, portable sawmills, rock crushers, grain threshers and other appliances.

An important source of mechanical power for farm use is the stationary gasoline engine, which came into wide use even before the tractor. The tractor has pretty largely supplanted the use of stationary and portable engines in sizes of 10 hp. and larger. The small sizes, however, have a wide field of usefulness. They furnish as nearly as many horsepower-hours of energy on American farms as do gas tractors.

The Motor Truck—From the standpoint of supplanting animal power, the most significant advance made by mechanical power in agriculture is in transportation to and from the farm and about the farm. The automobile and motor truck have all but driven the horse off the road. The automobile came into widespread use in advance of the tractor. And the motor truck has closely followed the tractor.

Both motor trucks and automobiles have greatly lowered the cost of transporting farm products to market, and purchased equipment and supplies to the farm. Not only have costs been greatly reduced by making it possible for the farmer to market his products more quickly but motorized transportation has enabled him to take advantage of more distant markets, and, incidentally, of better prices. Motor vehicles enable the farmer to spend less time going to and from town, and more productive time in his business. The automobile especially has been an important factor in helping the entire farm family to gain better educational, social and other advantages. No other single factor has been of such outstanding importance in raising the standard of living of farm people.



POWER FARMING SAVES LABOR AND TIME AND PRODUCES MORE THOROUGH WORKING OF THE GROUND

The motor truck, aside from its hauling uses to and from the farm, has even greater usefulness about the farm; hauling implements and supplies to and from the field, hauling crops from fields to buildings. In fact, it has an almost unlimited variety of uses.

Electric Power—The most significant and far-reaching development of engineering in agriculture during the past few years has been the application of electricity. Individual gas-engine-driven electric plants have been sold to farmers in large numbers, principally for supplying electricity for lighting and other uses where the current demand is not great. There has also been a very rapid and insistent demand from farmers for service from central power stations, and electric power companies are building many thousands of miles (100,000 miles in 1926) of distribution lines into rural districts. The principal demand for current is for lighting farm homes and other buildings, but it is also being used extensively for many household purposes and for many small motor applications about the farm, as well as for a few heavier motor applications; but the gas tractor is still the most economical form of power for the heavy belt work.

The introduction of electricity to farm use will undoubtedly have considerable influence on the development of farm machines, resulting in equipment better adapted for the use of electric power. A particular example is the development of a small feed grinder of the hammer type, suitable for grinding roughage as well as grains.

While the use of electricity in agriculture is still in its infancy, it gives promise of far-reaching importance and significance to the industry. Many engineering and economic problems are involved.

Improving Agriculture—The application of mechanical power and farm machinery has already had a great influence on agricultural methods, but the possibilities in this direction have scarcely been touched. Many of the present inherited methods of agriculture are a serious handicap to the development of agriculture along engineering lines. The engineers concerned with these problems are studying possible changes and improvements. For example, the production of row crops presents a difficult engineering problem, involving the use of much special machinery. The possibility of eliminating frequent cultivations, the standardization of widths of rows and changes in cultural methods are being given thorough study.

In the days when animal power was used exclusively, farmers seldom had sufficient power, principally because the extra expense involved would not permit it, hence they could not perform certain cultural operations as thoroughly as should be done. The tractor, however, has made it possible for farmers to do better work. With greater power available they are enabled to plow deeper and do a better job of preparing the seedbed for the crops to be grown. Incidentally, of course, much time is saved.

Reclamation Engineering—One of the important branches of engineering as applied to agriculture is that of land reclamation. This includes irrigation, drainage, terracing, reforestation, clearing and the development of reclaimed land for agricultural uses. Outside of the field of civil, mechanical and electrical engineering in the design and construction of the ways, structures and machines, which constitute the main works of the larger enterprises of reclamation, lies a large field for the application of agricultural engineering. The following items may be emphasized:

1. The work of the engineer in the service of the owner or occupant of land in a large reclamation project.

2. The agricultural and economic feasibility of reclamation projects.

3. The entire engineering and related fields in those types of reclamation which can be accomplished independently and completely on relatively small units of area.

4. Determination of the capacity requirements of channels and conduits in proposed irrigation or drainage work, as based upon crop requirements or tolerances and soil properties.

5. Planning, construction, maintenance and operation of unit ways, centers, structures and service.

The foregoing applies more particularly to the relation between the agricultural and non-agricultural phases of engineering as applied to irrigation and drainage.

Eastern Irrigation—The irrigation of agricultural land, once confined for the most part to the arid lands of the West, has now come into extensive use in the semi-arid areas east of the Rocky Mountains, and a great amount of spray irrigation, particularly in the growing of small fruits and vegetables, is being practiced in the eastern parts of the United States. Supplementary irrigation in the humid areas of the country, in the opinion of many engineers, has tremendous possibilities. It will probably not come into extensive use, however, except where intensive farming is practiced.

Three types of drainage are applied to farm lands: Open ditch, tile drainage and mole drainage. Many millions of acres of farm land in the humid areas have been drained, and yet it may be said that only a start has been made. A wet spot on a farm is a distinct loss to the farmer. It may delay or even prevent him entirely from putting a crop on the land, or the crop may be partly or entirely destroyed by flooding after being put in. Furthermore, it is expensive to farm around a wet spot. With the increased use of tractors and the need for greater efficiency in farming operations as a means of lowering costs, the need for squaring up fields, by eliminating wet spots by drainage, is becoming more and more important. Usually land when reclaimed is the most valuable on the farm.

AN IRRIGATION ENGINEERING RESULT
Strawberry farming in Colorado.

Checking Erosion—Control of soil erosion is one of the great engineering problems in agriculture. Investigations indicate that twenty average crops do not draw as much fertility from the soils of this country as is lost in one year by erosion. Agriculture cannot be profitable on farms worn out by erosion. Engineers have already made marked advance in providing the remedy for soil erosion by developing the practice of terracing rolling farm lands.

The clearing of stumps from cut-over timber land and the removal of large stones has been one of the big problems of agricultural engineering in certain sections of the country. It has called for the exercise of considerable engineering skill to develop methods of applying explosives for this purpose, and also in developing special machinery such as stump pullers, equipment for moving and piling stumps and plows for plowing land that has been stumped or that is covered with underbrush. There is not the activity in this field at present, however, that there has been in the past, due to the fact that present economic conditions discourage bringing new land into cultivation.

Farm Building Progress—The application of industrial ideas and methods to agriculture has emphasized the need of radical changes in the design and construction of farm buildings and in the planning and layout of the farm plant as a whole. In the production of dairy products in particular it has been necessary, in order to meet sanitary requirements, to give a great deal of study to ventilation and related equipment, to the design of stables and stable equipment, including floors, mangers, watering equipment, feed and litter carriers, and a host of other things, where engineering skill and a knowledge of the peculiar requirements are essential to the correct solution of these problems. Roofs and barn framing, to withstand wind loads and at the same time permit most efficient use of the interior space, call for real engineering. The arrangement and equipment for storing and handling feed used on the farm or crops to be marketed present many problems of a typical engineering nature.

The consideration of the various materials available for farm building construction, including lumber, concrete, hollow tile, brick, sheet steel and the various materials used for roofing and insulation, present engineering problems, from the standpoint of economy of construction and adaptability to the peculiar requirements. Some classes of farm shelters require a higher type and consequently more expensive construction than others. Engineers are, therefore, confronted with the problem of keeping costs at a minimum, but at the same time meeting other essential requirements.

In the development of farm buildings, scientifically adapted to the various production and shelter requirements, it is necessary for the animal husbandman to set up the fundamental requirements for the housing of dairy, cattle, sheep, hogs and poultry. With these requirements before him the engineer is in position to develop structures that will meet the conditions laid down. The engineer must go farther than this, however. In locating and designing different types of structures he must keep in mind their relation to one another and also their relation to the farm plant as a whole. There are tremendous possibilities in the layout and arrangement of farm buildings for saving labor, which, as in any industry, is the most costly item of production expense.

The rapidly increasing use of mechanical power and larger machine units, together with the ever-increasing necessity of reducing costs, is strongly emphasizing the need for more engineering in farm plant planning. Small, irregularly shaped fields, which are common under horse-farming conditions, are not adapted to the most efficient use of tractors and large machines. Larger and longer fields contribute greatly to increasing the efficiency of large mechanical power units. Also to reduce the time of movement of crops and machinery between fields and buildings the location of the buildings on any farm enterprise is of great importance. Moreover, many factors, including kind of crops grown, lay of the land and accessibility to good roads, affect this problem.

The Farm Home—One of the best services the engineer has rendered agriculture is in raising the standard of living on the farm. The importance of the automobile in this connection has already been mentioned. Practically everything in the way of city conveniences has now been made available to farm folks.

Modern engine or electric-motor-driven water supply systems make it possible to have water on tap not only in the home but at any place in the farm buildings. Thanks to the engineer, the disposal of farm sewage is satisfactorily and economically taken care of by the septic tank. Electricity is rapidly replacing the oil lamp. The housewife is using electricity extensively for electric irons, vacuum sweepers, fireless cookers, sewing machines, washing machines, cream separators, cooking and refrigeration.

The latest contribution to raising the standard of living on the farm is the radio, which has meant even more to folks on the farm than it has to people in the cities.

What Agricultural Engineering Is—The applications of engineering to agriculture as outlined in this article all fall within the scope of "agricultural engineering." Agricultural engineering has been defined as the engineering of the industry of agricultural production and concerns itself with the tasks and problems peculiar to that industry. Whereas agriculture is the oldest of all industries, agricultural engineering and the agricultural engineer are a comparatively recent development, yet 40 state colleges and universities in the United States are giving instruction in the various branches of agricultural engineering.

While a gradual change from hand and animal power to mechanical power and engineering methods and equipment has been taking place for many years, this change is now assuming a much more rapid pace. Mechanical power is the dominant characteristic of the present transition. In order to absorb the shock of this change, an unusual effort is required (1) to discover, through research, new principles and improved practices, (2) to develop new equipment and more efficient methods, and (3) to place at the disposal of the agricultural industry the information needed for the most effective application of engineering to agricultural conditions and requirements. Many problems of a strictly engineering nature await solution.

The invasion of the European corn borer for a time threatened seriously to curtail if not practically to destroy the corn-growing industry of this country. Entomologists for years attempted to check the borer, but without avail. The services of agricultural engineers were enlisted, and they have demonstrated that this pest can be effectively controlled by mechanical means. Much research, together with the development of new equipment and the improvement of farming practices, still remains to be done to effectively check the corn borer.

The never-ending war waged by farmers against weeds and insect pests is a costly one. Once the requirements for control have been set up by agricultural scientists, the problem becomes one for the agricultural engineer to carry out. This involves the design, production, application and efficient use of suitable machinery. It is in fact largely a machinery problem. If it were possible to estimate the percentage of farm production costs required to fight weeds and insects, the importance and extent of the control problem would loom surprisingly large.

Changes in agricultural production methods and requirements are creating a demand for many new and improved machines: corn-borer equipment, hay driers, grain-drying equipment, soy bean harvesters, cotton harvesters, corn harvesters and soil tillers. The design, production and application of such equipment are fundamentally an engineering problem.

Another agricultural engineering problem of basic importance has to do with soil dynamics—that is, the determining of the factors in soils governing the action and production of tilth, and the development of implements that will accomplish the desired result with a minimum utilization of power.

There is great need at present for agriculture to discover new uses for its products, so that processing plants may be established close to the supply of raw material. This will provide employment for some of the less efficient agricultural workers, and at the same time a possible outlet for a surplus of farm products will be secured. By finding new uses for the byproducts of agriculture much of the present waste in the industry will be reduced. An example of this is in the manufacture of wall board and paper pulp from corn stalks.

Future Possibilities—There are indeed tremendous possibilities for the engineer, not only in the field of agricultural production but no less so in the field of agricultural manufacturing. Engineering problems, plenty of them, are to be found in all branches of agriculture. In fact, there are few problems in the field of agricultural research and production that do not involve more or less engineering. No other field today offers bigger opportunities for the engineer, and in this connection it must be remembered that agriculture is not only the greatest but also the most fundamental and the most essential of all industries.

FARM HOME AND PLANT BUILDINGS OF THE ENGINEERING ERA

Mississippi River Flood Control

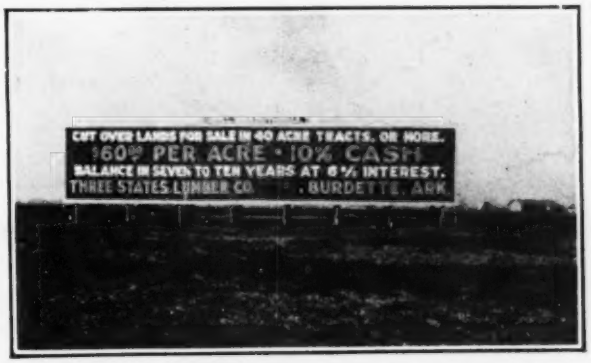
A Brief Summary of Events and Conditions — The Engineering Problems Presented by History's Greatest Flood in Valley—Some of the Many Factors Which Must Be Considered in Preparing Plans for Flood Relief

By W. W. DeBERARD
Associate Editor, Engineering News-Record, Chicago, Ill.

WITH 1928 the American nation enters definitely on the task of dealing with the problem of the Mississippi. Six months' study and reflection has been given to the problem; the magnitude of the task has been approximately revealed; and plans resulting from studies by the Mississippi River Commission and by the Chief of Engineers of the Army have just been published.

Where does the problem stand today? A review of the situation may help the reader to an adequate conception of its magnitude.

Probably no greater engineering problem has ever confronted a nation. With 31 states, contributing water which must seek its ocean level through the Mississippi channel, it embraces a multitude of conditions, from too little water in the semi-arid watersheds of the western portions to excessive precipitation and runoff in the funnel-like outlet through the delta country. This delta funnel, geologically an arm of the Gulf of Mexico up to Cairo, exhibited its inadequacy in 1927.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BREAKING UP LARGE LAND HOLDING IS BECOMING A NECESSITY

All that modern science and experience had developed was brought into service as a preventive in the emergency resulting. When disaster after disaster occurred, in the successive levee breaks with attendant flooding of back country, every agency of rescue, of concentration and of temporary care of victims was commandeered. Finally, when the waters had receded came the work of rehabilitation, not yet completed.

The job now is back in the hands of the engineer—his to handle, his to solve, his to plan, his to estimate, his to fight for legislation, finance and organization; his to build and, lastly, to maintain and operate. Responsibility such as this, an empire of 20,000 sq. miles to be saved from inundation, has never before so clearly and definitely challenged a profession.

That engineers are facing this responsibility with the seriousness which its magnitude and intricacy deserve constitutes a reason for pride in the whole engineering profession.

The Problem—To state the problem in few words is not easy. Primarily what requires to be done is to provide a means of passing safely down a thousand-mile level channel the maximum runoff to be expected from extreme possible combinations of floods in the river's five principal tributaries. But just how large may be this flood and how distributed, and just what widths of channel can be made available, is less readily answered.

First must be considered the rainfall, then the runoff, then the concentration and finally the cross-section and slope furnishing the head to drive the fluid load to its destination. The 1927 flood, analyzed as to crests produced in the single channel as it now exists, has ruthlessly shattered all previous views that "levees only" will suffice. The river cross-section as defined by the present development of the banks simply has not sufficient capacity. We now know that like an overloaded railroad it has too much business at peak load; unlike the railroad it cannot embargo freight, and so it broke bounds all along the line when the crest reached succeeding stations. Widening the main river channel width to peak-load capacities is a plain impossibility, from the financial and structural considerations, as even the roughest shirt-cuff calculations can show.

Auxiliary means of carrying water are thus forced into the problem. And at once the whole matter becomes intricately involved. What are some of the auxiliary possibilities?

Reforestation, with its long-time cumulative effect, has advocates ranging from members of the forest service—who acknowledge freely that reforestation can have but minor effect on a duplicate of the 1927 flood—to timber-growing enthusiasts who would have the government buy up the whole St. Francis basin at high prices per acre, flood it when necessary, but grow timber therein and resell at low figures to private interests.

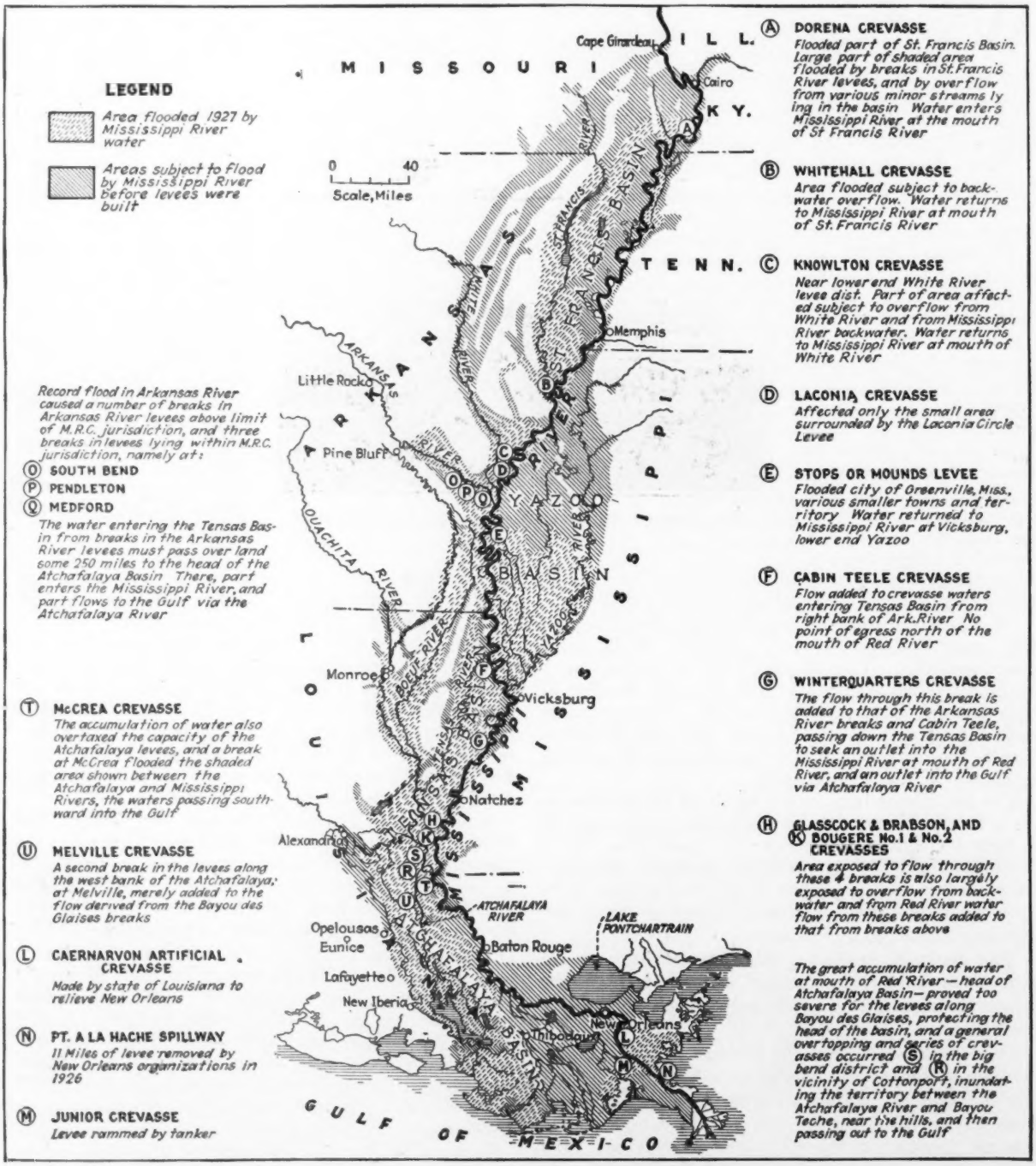
Reservoirs are entitled to favorable consideration, say many enthusiasts. They have allied with them all of the municipal power-plant people. Reservoirs are urged also by the irrigationists of the semi-arid regions, who offer statistics of losses from drought three times as great as the flood loss and further claim a nitrogen loss of 1 lb. per bushel of wheat as against a gain of nitrogen by the delta. The Chief of Engineers' report does not satisfy these advocates. They do not find in it information on silt content, on the size of the load pushed along the bottom, or on the horsepower in terms of head and gage height required to shove it along. Humphreys and Abbot back in Civil War days made some tests which are good as far as they go but the detention people want to know all about silt and actual current-meter discharges.

Many of the reservoir partisans are reasonable and do not claim that reservoirs can do more than help in a small way. But they join with the reforestation people in pointing to the bare plains of China, to the spring

dike-breaking of the Nile and the value of the fertilizing silts. That they are entitled to a hearing eventually is conceded by General Jadwin, whose report classes all these auxiliary means as subjects for investigation and survey connection with later studies of the tributaries.

The difficulty with the reservoir proposals as a flood-control measure of any significance is that, as Col. William Kelly, chairman of the Reservoir Board, has very clearly stated, one after another of the practical reservoir possibilities has "washed out" when carefully examined, until practically nothing is left. For example, a site that looked excellent could not be filled for lack of water, unless water were brought in from other tributaries by diversion channels costing many millions. Certain small reservoir projects will be found, no doubt, but they can only be considered as refinements of the main solution.

Channel Auxiliaries—If the river can not be widened and the water can not be detained, the only remaining alternative is to provide more channel capacity outside of


LEGEND
Area flooded 1927 by Mississippi River water
Areas subject to flood by Mississippi River before levees were built
0 40
Scale, Miles
Record flood in Arkansas River caused a number of breaks in Arkansas River levees above limit of M.R.C. jurisdiction, and three breaks in levees lying within M.R.C. jurisdiction, namely at:
(O) SOUTH BEND
(P) PENDLETON
(Q) MEDFORD
The water entering the Tensas Basin from breaks in the Arkansas River levees must pass over land some 250 miles to the head of the Atchafalaya Basin. There, part enters the Mississippi River, and part flows to the Gulf via the Atchafalaya River
(T) McCREA CREVASSE
The accumulation of water also overtaxed the capacity of the Atchafalaya levees, and a break at McCrea flooded the shaded area shown between the Atchafalaya and Mississippi Rivers, the waters passing southward into the Gulf
(U) MELVILLE CREVASSE
A second break in the levees along the west bank of the Atchafalaya; at Melville, merely added to the flow derived from the Bayou des Glaises breaks
(L) CAERNARVON ARTIFICIAL CREVASSE
Made by state of Louisiana to relieve New Orleans
(N) PT. A LA HACHE SPILLWAY
11 Miles of levee removed by New Orleans organizations in 1926
(M) JUNIOR CREVASSE
Levee rammed by tanker
(A) DORENA CREVASSE
Flooded part of St. Francis Basin. Large part of shaded area flooded by breaks in St. Francis River levees, and by overflow from various minor streams lying in the basin. Water enters Mississippi River at the mouth of St. Francis River
(B) WHITEHALL CREVASSE
Area flooded subject to backwater overflow. Water returns to Mississippi River at mouth of St. Francis River
(C) KNOWLTON CREVASSE
Near lower end White River levee dist. Part of area affected subject to overflow from White River and from Mississippi River backwater. Water returns to Mississippi River at mouth of White River
(D) LACONIA CREVASSE
Affected only the small area surrounded by the Laconia Circle Levee
(E) STOPS OR MOUNDS LEVEE
Flooded city of Greenville, Miss., various smaller towns and territory. Water returned to Mississippi River at Vicksburg, lower end Yazoo
(F) CABIN TEELE CREVASSE
Flow added to crevasse waters entering Tensas Basin from right bank of Ark. River. No point of egress north of the mouth of Red River
(G) WINTERQUARTERS CREVASSE
The flow through this break is added to that of the Arkansas River breaks and Cabin Teele, passing down the Tensas Basin to seek an outlet into the Mississippi River at mouth of Red River, and an outlet into the Gulf via Atchafalaya River
(H) (K) GLASSCOCK & BRABSON, AND BOUGERE No.1 & No.2 CREVASSES
Area exposed to flow through these 4 breaks is also largely exposed to overflow from backwater and from Red River water flow from these breaks added to that from breaks above
The great accumulation of water at mouth of Red River—head of Atchafalaya Basin—proved too severe for the levees along Bayou des Glaises, protecting the head of the basin, and a general overtopping and series of crevasses occurred (S) in the big bend district and (R) in the vicinity of Cottonport, inundating the territory between the Atchafalaya River and Bayou Teche, near the hills, and then passing out to the Gulf
MISSOURI
ILL.
KY.
TENN.
MISSISSIPPI
Cape Girardeau
Cairo
Memphis
Little Rock
Pine Bluff
Monroe
Vicksburg
Natchez
Alexandria
Opelousas
Eunice
Lafayette
New Iberia
Baton Rouge
Thibodaux
New Orleans
LAKE PONTCHARTRAIN
ATCHAFALAYA RIVER
ATCHAFALAYA BASIN
ST. FRANCIS BASIN
YAZOO BASIN
WHITE RIVER
ARKANSAS RIVER
OUACHITA RIVER
RED RIVER
BOEUF RIVER
TENSAS RIVER
YAZOO RIVER
GULF OF MEXICO

PORTION OF THE MISSISSIPPI RIVER VALLEY SUBJECT TO OVERFLOW

Shaded area shows land subject to overflow before levees were built and during 1927 flood. Major breaks in the levee line during 1927 flood indicated by letters.

the present banks and levees. And that is where most of the present engineering thought is being directed. Floodways along the river bank from Cairo to New Madrid, and down the Tensas and Atchafalaya Basin to the Gulf, form the major flood-relief devices recommended in the two reports. Diversion by a controlled spillway above New Orleans is called for in the Chief of Engineers' report; others prefer a spillway below the city, and still others would provide two—one above and one below.

Lack of information on reduced channel capacity due to silting will continue to be the bugbear of the diversion problem until some new and accepted measurements of silt becomes available. Yet floodways must be the backbone of relief for great floods of the Mississippi. Many factors need to be studied aside from the cost of widely separated levees. Basically, rainfall distribution and runoff form one group of factors, while the economic conditions in the territory to be benefited or taken form the other.

Rainfall.—The 1927 precipitation from Dec. 18 to April 30 was equivalent to 10.8 in. in depth over the whole catchment area of the Mississippi system, an excess over the greatest previous flood year (1922) of 1.8 in. If the upper third of the area is disregarded, since it does not contribute materially, the precipitation was 16.3 in. of water, or 2.6 in. more than in 1922.

MOUND OF REFUGE BUILT BY INDIANS

Unprecedented intensity of rainfall occurred in eastern Oklahoma, western Arkansas, and southern Missouri at a time when the Mississippi channel was already surcharged. Thus there came out of the Arkansas almost as much water as was already in the Mississippi itself. It was inevitable, then, that levees should break along the lower Arkansas and should restore Nature's floodway through the west-side bottoms to the head of the Red-Atchafalaya system; and it was just as inevitable that the Bayou des Glaises levees should thereupon break and pass the bypassed flow down to the Gulf through that other natural floodway, the Atchafalaya. It is just these two floodways, Tensas and Atchafalaya, that General Jadwin would restore deliberately, as regular means of flood relief.

No other solution is possible—unless levees on the main river were to be moved back five or six miles, an unthinkable procedure, which would destroy most of the highly cultivated lands that now pay the taxes of the river countries and comprise the richest of the agricultural development on the river.

But what of the development in the Tensas Basin and in the Atchafalaya, where the floodways are to be formed? Can they stand an occasional flooding and still exist? Is it worth while to develop a sugar cane plantation with levees to hold water on, rather than away from, one's holdings? Here the question shifts to economic matters; and they are far from simple.

Economics of Land Use—The project obviously must first of all contemplate providing refuge hills for the floodway population, and also loop levees around future towns sure to spring up, as well as around individual plantation centers. But even with such necessary safeguards, how about the cotton grower in the Tensas basin? What land valuations will he contend for? Keeping land values in mind, how wide should the floodway be made, and what is the balance between greater width and higher floodway levees?

In arriving at general valuations, one is dependent on so many elements of variation that the outcome is soon seen to be at best a matter of trained guessing. Even figures from the best sources available can be given only limited weight with respect to the entire widely spread situation. Sugar plantations are sold on the basis of so much tillable land; cotton growers usually lump their whole acreage, though fully half of it is apt to be swamp and timber. Present-day valuation, asking price and earning power value are divergent from each other and from prospective value.

The agricultural population in the South seems to have been suffering from the same general depression, due to much the same causes, as the wheat and corn growers, namely, surplus production and inefficient marketing. Its plight before the flood was probably not materially worse than that of other farmers. There were the same deflation problems. Nebraska bank officials say that practically all the financial institutions in that state would have gone under in 1927 had it not been for deliverance by the combination of good crops and good prices last fall. Quite similarly, at the present moment the optimistic cotton grower and his banker in the delta flooded-land districts are looking to 1928 for like deliverance.

The sugar-cane grower admittedly was practically down and out before the flood. Diseased cane had reduced his yields to bankrupt figures. Now he sees prosperity ahead in the new P.O.J. varieties, tolerant of the mosaic disease, which science has discovered for him.

How Land Is Used—In the progression of agricultural development southward from Cairo to the Gulf a series of changes may be observed. First comes the corn farmer of Missouri, with comparatively small holdings. Then comes corn with a little cotton in upper Arkansas, and cotton with a little corn in southern Arkansas and upper Louisiana. Plantations get larger as one goes south. Few real-estate signs advertising small acreages for sale are to be seen in a 2,000-mile trip down the delta.

Farther down in Louisiana come the sugar planters, with local plant-disease problems. This is a comparatively small group, because of climatic restrictions; yet it is a factor of the total situation because of the high potential crop values and their location within the path of the proposed Atchafalaya floodway. Perhaps there should also be noted the truck farmers with their small holdings, an arpent (about 200 ft.) or more wide and 1 to 3 miles long, the narrow end abutting on the river bank above and below New Orleans. The trappers of the swamps must also be considered, as those can testify who had to arbitrate the damage claims arising from the Caernarvon cut, below New Orleans.

Neither the Mississippi River Commission report nor that of the Chief of Engineers attempts estimates of property costs and damages, though some of the maps show the percentage of swamp and timber lands within the proposed floodways (40 per cent for the New Madrid setback, 60 per cent for the Boeuf Basin and 80 per cent for the Atchafalaya). It will be necessary to invest someone with dictatorial power to allocate land inside or outside of the floodways and the set-back levees. That power can be wielded with for less chance of upset by local or political interference, if reliable data are first obtained.

Cost Apportionment—No paragraphs on economic conditions would be complete at this time without mention of the apportionment of cost between the nation and the local interests.

President Coolidge has laid down the only safe method of procedure. Government philanthropy can extend only so far without risk of the nation's degenerating into the condition of England with its dole system. The evil results of reclamation of arid lands of the West by loans from a revolving fund need to be kept in mind. Delta-land protection and arid-land reclamation are not so different but that a parallel may be drawn.

At bottom the justifiability of protection of a given area rests on the criterion of whether present and future returns from that area can pay for the work of protecting it. Where cost outweighs returns, protection becomes extravagance. Beyond this point floods must be allowed to work their will freely, like wind and tide. If people then insist on exposing themselves or their property, they must consider flood destruction as an act of God, not as preventable disaster.

If this be granted, then surely the delta farmer should be willing to share in the cost of flood-protection, *up to the point where an economic return can be shown.* Above that point, the country at large may cover a further item of cost, for reasons of general welfare and humanitarian benefits.

One of the principal difficulties in apportionment comes from the fact that the total cost of construction plus easements, property costs and damages has not yet been computed. Moreover, the losses of the local people, their legal rights, both proprietary and obligatory, all should be appraised when apportionment is decided. The delta region has already paid a goodly share, and this should be figured in making the apportionment. The ultimate result must be a joining of equity and philanthropy.

Should the costs of real estate or right-of-way for the protective works be borne locally? This, too, has been much disputed pro and con. The simplest answer was phrased for the writer by an engineer. "If," said he, "I own a lot and you are to build a house for me and give it to me, *the least I can do is to furnish the lot.*"

Taken in its entirety the Mississippi Valley problem is peculiarly a problem of the engineer. But the engineer needs the assistance of all the other scientists and technicians—the meteorologists, hydrologists, geologists, agricultural experts, economists, lawyers, bankers, humanitarian philanthropists—as well as of true statesmanlike politicians. The enterprise needs a centralized organization of continuing personnel, receptive to scientific development and research, clothed with authority to carry through its projects without excessive red tape, and imbued with a spirit of enthusiasm in keeping with the magnitude and vital importance of the project. It requires financing unrestricted by the threat of discontinuing appropriations. It needs local support of the states benefited, to preserve local interest, selfrespect and freedom from the danger of profligacy.

To bring together all these things an adequate plan thought out in the light of all the salient factors must be produced. Very much further information on the main underlying factors must still be obtained—a point so thoroughly supported by all competent authorities that it is plainly logical to make the search for this information the first step toward progress. Both the Chief of Engineers and the Mississippi River Commission have achieved remarkable performance in drawing up their reports; but the extensive difference of opinion between the two is plain proof that more light is needed before one plan can be chosen.

And last but greatest of present needs is wise congressional authorizations of finance and administrative organization.

RESCUE WORK IN THE FLOODED LANDS OF THE MISSISSIPPI VALLEY

Earth Moving Mechanized

Development of Excavating Machinery Since the Invention of the Power Shovel Has Produced Equipment Suited to Widely Varied Conditions — Its Distinctive Types and Their Fields of Application are Here Outlined

By CHARLES H. PAUL
Consulting Engineer, Dayton, Ohio

LARGE-VOLUME earth moving in work to day has at its service the largest and most powerful armament of machines employed in engineering construction. These great tools have developed gradually during the century since the time when locomotive and steam shovel first made it possible to apply mechanical power to digging the ground and transporting it to another site. But only within the last two decades have they taken on their present-day characteristics of mobility, adaptability, multiplicity of purpose, enormous capacity and general mechanical excellence. It is timely to indicate the general results of this transformation.

This article will not undertake to trace development; it cannot do more than to inventory, as of today, the power tools available for the mass excavation, transportation and placing of earth, and briefly to define their particular fields of usefulness. These tools are of three general types, corresponding to the three functions just indicated.

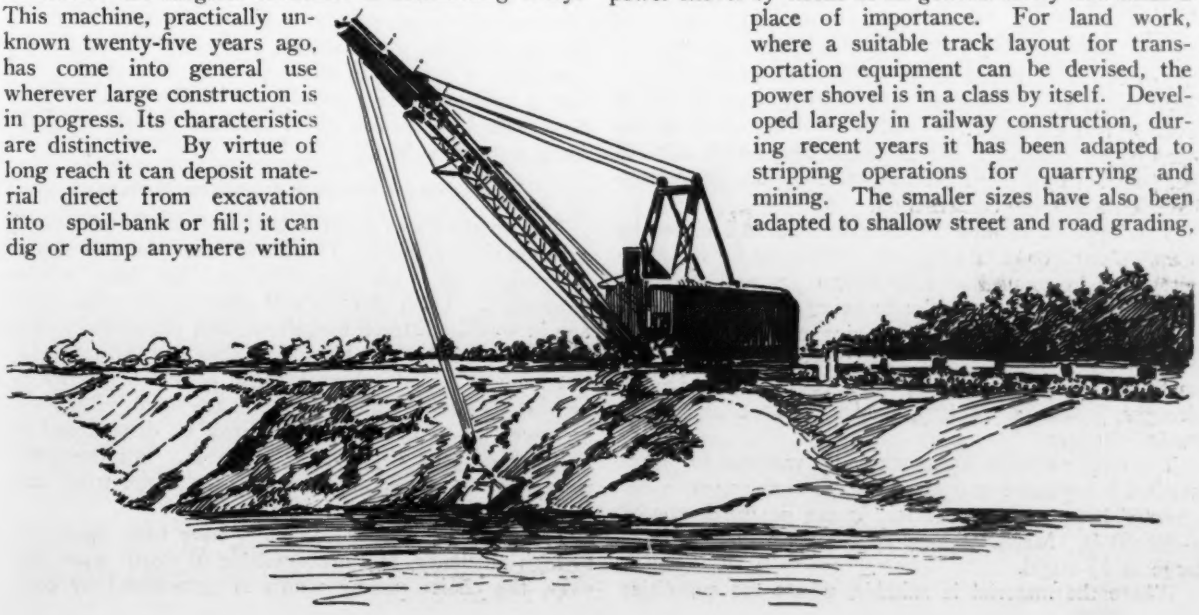
Machines for Excavation—There are few kinds of earth excavation for which machines are not available. This assertion includes special-purpose excavation such as trenching and tunnel boring. Machines for general excavation are of controlling importance. There are machines of this type available for use in virtually every kind of open-cut or pit work, either in the dry or under water.

Dragline Excavation—Among these general-purpose excavators the dragline excavator is outstanding today. This machine, practically unknown twenty-five years ago, has come into general use wherever large construction is in progress. Its characteristics are distinctive. By virtue of long reach it can deposit material direct from excavation into spoil-bank or fill; it can dig or dump anywhere within a circle whose radius is determined by the length of the boom. It can build its own trackway ahead, and can clean up behind as it moves. It is an effective substitute for a derrick or a locomotive crane in handling heavy loads. It can load cars almost as economically as can a steam shovel, and because of its long reach its use with cars requires much less track work than does the latter.

It has been used successfully in rock cuts. It can pull down a bank standing high above the level at which it is working, and can excavate a pit far below where it stands. This latter ability makes it especially valuable where part of the material to be excavated lies below water level; here the dragline can operate from the top of a cut, out of danger from flooding, and its work is almost as efficient as when working in the dry. No other excavating machine is adaptable to so many different kinds of work.

Dragline excavators are built in a wide variety of sizes with considerable choice permissible in type of mounting and kind of operating power. For the smaller machines crawler tractions are common; they provide a remarkable degree of mobility. This type of mounting, however, has not yet come into general use on the larger machines, which are generally carried on skids and rollers or on trucks. Steam or electric power is standard for machines of all sizes, but on the smaller machines gasoline and oil engines are also used extensively. Very recently Diesel oil engines have been adapted to the larger draglines.

Power Shovels—Earliest of modern excavators, the power shovel by virtue of its general utility still holds a place of importance. For land work, where a suitable track layout for transportation equipment can be devised, the power shovel is in a class by itself. Developed largely in railway construction, during recent years it has been adapted to stripping operations for quarrying and mining. The smaller sizes have also been adapted to shallow street and road grading.



and to foundation work and excavation for small structures, for which formerly the excavation would have been handled by teams and scrapers or pick and shovel.

The standard power shovel not many years ago was the boom swinging type. Now full revolving shovels are made in all sizes, from small ½-yd. dipper machines to those carrying dippers with capacity of 8 cu.yd. or more.

One of the most spectacular of these newer machines is a full revolving shovel, on crawler tractions, carrying a 15-yd. dipper. This has been put on the market only during the last few months, and commands attention not only because of its large dipper capacity but also because it is by far the largest piece of construction equipment for which crawler traction has been worked out successfully. More commonly the larger shovels have railway-truck mounting, while small shovels have either wide-tired traction wheels or some form of crawlers.

Steam was originally the exclusive power. Today the larger sizes may be obtained with either steam or electric power or Diesel oil engines, and the smaller shovels with steam power, electric power, gasoline power or a combination of gasoline and electric power. The wide choice permits of adapting the machine closely to the controlling conditions of operation.

Slackline Cableway Excavators—The slackline cableway excavator has been developed particularly for gravel pits and similar open excavations where large quantities are to be excavated within a limited area. The maximum practicable span is about 1,000 ft., but most satisfactory results are obtained with smaller spans. The tower end of the cableway is usually fixed, and the anchorage at the other end is moved about, so that without moving the head tower this equipment will cover a large sector, or even a full circle, whose radius is determined by the span of the cableway. Slackline cableways with movable head-towers have been used successfully on channel excavation and levee construction.

This type of equipment may be operated either by steam, electric or gasoline power. While by far its greatest use is in connection with gravel pits and stripping operations, its use is gradually being extended.

Dredges—Machines for removing earth under water are among the largest and most powerful in the entire earth-moving field. They fall into four classes: Dipper dredges, hydraulic dredges, ladder dredges, and grab-bucket dredges.

The dipper dredge is best where the material to be excavated is hard and compacted, or where the work is obstructed by stumps or débris. It can dig to depths of about 50 ft. Machines have been built with dippers as large as 15 cu.yd.

Where the material is suitable, where the quantities are large, and where the spoil material may be deposited within a reasonable distance, the hydraulic dredge holds a unique position. Pumps for these dredges range from 10 to 24 in.; the 20-in. pump is a common size for large jobs.

Ladder dredges in this country have been limited largely to placer mining operations, where the material can be worked over and re-deposited in the same general locality. However, in individual instances the ladder dredge has been used successfully for general excavation, where because of great depth or for other reasons this particular type showed an advantage. The digging buckets vary in size from 7 to 13 cu.ft. for hard digging, and from ½ to 1 cu.yd. for soft material.

The fourth type, the grapple or grab-bucket dredge, has a field which is somewhat limited due to the fact that the operation is necessarily slower and less positive than with most other types. Its choice is therefore confined to those jobs where special conditions require the use of a grab-bucket.

All four types of dredges are steadily being improved and adapted to more varied conditions. During recent years the most noteworthy progress has been that made in the development of the hydraulic dredge, which has been advanced through decisive improvement in the durability and efficiency of the dredge pump.

Hydraulic Monitors—The hydraulic monitor, or giant, requires special conditions to justify its use for excavation. The material must be such that it can be broken down by a powerful stream of water under pressure. The available slope must be sufficient to permit the transportation of the material in a sluiceway or flume from the point of excavation to the point of deposition. And last a sufficient water supply, preferably under a head high enough to furnish direct pressure for operating the giant, must be at hand.

Transportation of Excavated Material

Transportation of earth in large volumes is universally a mechanical process. The horse, once the sole source of power for such transportation, has been wholly eliminated. True, there is still some use of team haulage in small, scattered operations, and occasionally on a larger operation where tractors, trucks and railways cannot be used to advantage because of inaccessibility or because individual units of volume are small. But these instances are quite special, and may be disregarded in thinking of general-purpose excavation. For the latter the horse has ceased to exist, and the motor-truck and the tractor have taken its place.

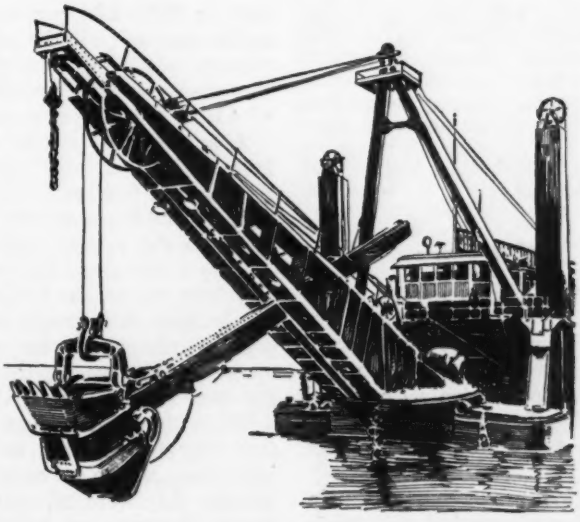
Tractors and Trucks—Tractors have been developed to high efficiency, and are available in many types and sizes, the choice among which is determined by con-

ditions and personal preference. The crawler-traction types are particularly effective in earth moving because of their ability to travel, and to develop pulling power, on soft ground. Because of its power the tractor, to be most efficient, requires large loads and continuous operation. This is also true of motor trucks. The most economical operation for motor-truck hauling is one where the idle time is small compared with the hauling time.

Locomotives and Cars—Steam locomotives with dump-car trains are the outstanding mechanical means for rail transport of materials. Cars of 3 or 5 yd. capacity are commonly used, with small locomotives, to operate on narrow-gage track; larger cars of 12 to 20-yd. capacity, with 40- to 50-ton locomotives, are used on standard-gage track.

The tendency in recent years has been towards the use of heavier rail in the tracks over which these cars operate, as it is being realized more and more that the condition of the track very often means the difference between successful and unsuccessful operation of the trains. On standard-gage installations, where 40- or 50-lb. rail was considered heavy enough in former years, it is now common practice to use rail as heavy as 60 to 70 lb., and a similar increase has been made in the weight of the lighter rail used for narrow-gage installations.

Belt Conveyors—A discussion of transportation equipment would not be complete without mention of belt conveyors. Following their application to gravel plants and rough outside work, as distinguished from shop use belt conveyors have been used successfully in the transportation of excavated materials on several construction jobs, including the building of dams. Grades as high as 25 to 30 per cent have been negotiated in handling sand and gravel, and for lighter materials such as top soil a grade of about 36 per cent has been used successfully. There seem to be no serious mechanical difficulties involved in the installation of belt conveyors for a wide variety of uses in handling excavated materials in construction operations.



Equipment of the several types used for excavation and transportation of materials is usually a part of the plant installation for embankment construction. In the case of levees, railroad fills, and the like, often no other equipment is necessary, while for many types of earth-dam construction the only equipment required especially for the embankment work may be sprinkling wagons, rollers and perhaps some of the equipment most commonly used for spreading.

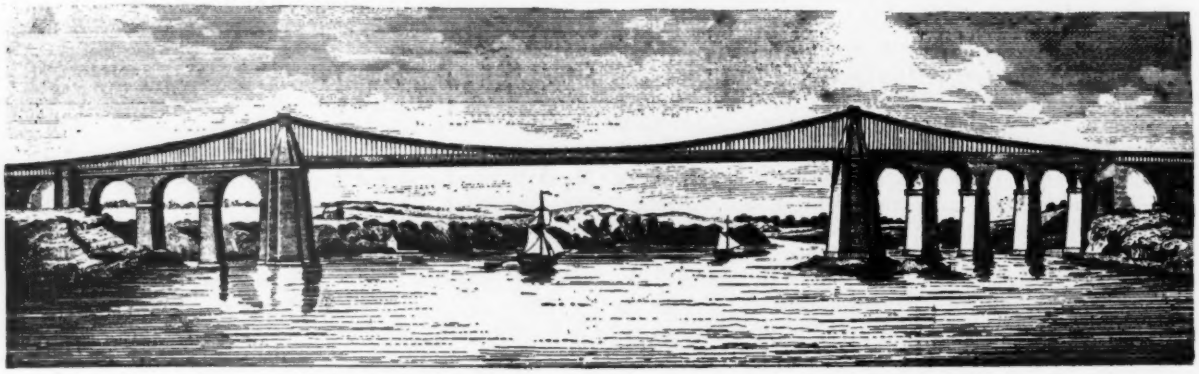
The special type of fill construction involved in hydraulic-fill dams shows marked progress during recent years through the development of dredge pumps. Hydraulic filling at the beginning consisted of sluicing materials from a higher level to a lower one, and therefore one of the requirements for the first of the hydraulic dams was that suitable borrow-pit material be located at a higher level, and that a sufficient water supply at the higher level be also available. A later development was to pump the water supply from a lower level when necessary, either to supplement or perhaps to replace entirely a high-level supply. But during more recent years it has been found practicable to take the borrow-pit material itself from a lower level, and to raise the embankment material into place by means of dredge pumps.

Improvement of Dredge Pumps—Originally these pumps were made of cast iron or semi-steel, with runners or impellers of the same material. For the lighter and less abrasive materials, such as are so often found in harbor and river work, this type of pump was fairly satisfactory, but when it came to handling the heavier gravel materials, such as are desirable for dam construction, the wear and tear on the pump was extremely heavy. This involved not only the cost of parts for frequent replacements, but also the loss of time while these replacements were being made. A step forward was the use of manganese steel for the impellers. Following that, manganese steel shoes were designed for use on the impellers, so that instead of discarding the old impeller when the tips of the vanes had been worn off, it was only necessary to put on a new set of shoes.

Following the satisfactory use of manganese steel for impellers and shoes, the next forward step was the introduction of manganese steel shells. These gave more than double the length of service that the old cast-iron shells were good for. Experiments have also been made with various mixtures based on the well known white iron formula. It is now possible to obtain, at reasonable cost, dredge pumps of special metal less expensive than manganese steel which will give excellent service.

Along with the improvement in durability and economy of dredge pumps, similar progress has been made in the manufacture of dredge pipe for the discharge lines from these pumps. Originally, standard dredge pipe was a riveted pipe of mild steel. Today the common practice is to use for that purpose a high-carbon electrically welded pipe which gives about three times the length of service as the other, and at almost no increase in cost of pipe.

Conclusion—Because of all this development in the mechanization of earth moving, the contractor today can undertake earth work of almost any magnitude with full assurance that he can find suitable equipment. Moreover, he can meet time schedules and more exact specification requirements, minimize the effects of unfavorable weather conditions and other contingencies, and can handle his work with a precision and confidence which would not have been possible even ten or fifteen years ago. This is being emphasized constantly by speed and cost records which are being made and results which are being accomplished in all the major earth-moving operations.



Telford's Menai Straits suspension bridge, a toll bridge built in 1826 and still in service

Some Thoughts on Toll Bridges

Some Notable Early Toll Structures, and Greater Possibilities Due to Modern Demands—Factors of Toll Policy as Related to Private and Public Interests and the Relation of Bridges to Roads—Great Bridges, Their Life and Preservation

By GUSTAV LINDENTHAL
Consulting Engineer, New York City

MANY GREAT BRIDGES are being built today, in answer to the demands of motor-vehicle highway traffic. Most of them are to be toll bridges, privately or publicly financed. In the growth of this new and remarkable activity, a variety of questions, both engineering and financial, has arisen, and there remain numerous questions as yet unanswered. The following reflections on the situation are based on a lifetime of distinguished service to the bridge-building art. —EDITOR.

1. *Some Notable Early Toll Bridges*

WHEN we contemplate the rise of the toll bridge in recent years, prominent examples from early years come to mind. One of the great structures built at the beginning of the civil engineer's professional era, Telford's suspension bridge over Menai Straits, for many reasons claims first notice. It is still in service, and has outlived many iron bridges built much later.

The chains of this historic bridge are of course its main elements of strength. Their workmanship was crude compared with present standards. Bars and bolts had been roughly fitted, with little machining, and the unit stresses in the bars were far from uniform and for many of the bars were rather too close to the elastic limit of the wrought iron. Yet the structure has stood up safely under the stress of heavy gales and under steadily increasing loads for one hundred years.

The eyebars had been formed by welding the eyes to the bars. On recent testing, fractures occurred through these welds at rather low limits. It is now proposed to replace the long span of this bridge with steel arches designed for heavier loads.

The next prominent chain bridge, in point of time, was the beautiful chain suspension bridge at Budapest, all of English iron, built 20 years later (1846). It suffered markedly from corrosion, but it was repaired ten years ago and now is as good as ever.

The Point Bridge over the Ohio River at Pittsburgh, built in 1876, fifty years after Telford's work, was the eyebar suspension bridge of longest span (800 ft.). Only recently was it replaced by a cantilever structure. Here also the welds were weakest; some broke under a stress of 43,000 pounds per s[illegible] inch.

About the same year [illegible] Bridge Captain Eads built his St. Louis steel ar[illegible]ge. This structure was designed for live loads 50 per cent higher than any other railroad and highway bridge of that time, but it is now too weak for present loads.

Only a few years later than the Eads bridge was the Brooklyn suspension bridge, completed in 1883, also a toll bridge. It is worth special remark, in view of the peculiar present-day importance of eyebars, that the eyebar anchorages are the weakest part of this bridge, but they are efficiently protected against corrosion.

While these old bridges tell us much of the long life that may be expected in well-built bridges, they are interesting also in an economic sense. All of them toll bridges, they were expected to last forever and to be a source of permanent revenue. Most of them soon became public property.

Toll bridges had been a favorite investment since antiquity. The toll plan may be said to have furnished the first incentive for economic design when spans other than the very shortest were required, and when a minimum of capital was available. Private capital is more enterprising and has always been more readily obtainable for building large and costly bridges than public money from taxation.

As we are building mainly highway bridges today, so the early bridge work was all for highway service. But it was the engineering skill gained in this work that enabled bridge builders to be prepared with adequate experience to furnish the stronger structures needed for locomotives, when the railroad era came in.

Still later, new problems in bridge construction arose from the demand of the navigation interests for longer spans and greater heights. And so it has come to the

significant situation of the present decade, a time of great bridge construction. Bridge engineering science has had to solve the question of cheapening the construction of long spans to make them commercially feasible in locations and over wide rivers where before no

CHAIN SUSPENSION BRIDGE AT BUDAPEST

bridge was thought practicable. Financial methods also had to be evolved for making possible the costly bridges demanded by modern highway traffic.

2. *Toll Bridge Finance and Policy*

IT IS only natural that toll bridge investors favor specially strategic locations, that is, locations not readily affected by competition for tolls. They wish to have their investment secure. But this in turn brings about a certain spirit of opposition to bridges on the part of the traveling public, as fear that the avenues of highway traffic would be blocked by too many toll gates. It was an expression of this spirit when the Bureau of Public Roads at Washington several years ago adopted the principle that it would not grant federal money aid to a public highway whose principal service would be to function as approach to a private toll bridge.

There is another and more perplexing element entering into the problem of toll-bridge finance. This is the threatened or actual competition of free bridges built at public expense, paralleling a previously built toll bridge, which in this way has its revenues impaired, it may be to the extent of actual loss of invested capital. The risk of such competition may have the effect of stopping the building of some necessary structures by private capital—a result that obviously works to the economic injury of the locality.

We see, therefore, that careful study and planning of traffic conditions in any locality should precede the building of toll bridges. The complex conditions of toll investment point to the necessity of going hand in hand with the local authorities and having agreements with them beforehand as to the extent and share of the work to be done by private capital and the share to be done with taxpayers' money. Unquestionably the cost of a bridge must in any case be borne by the public, either in the form of tolls or in the form of higher taxes.

There are not a few cases in which the demand for a highway bridge could have been met cheaply by building the highway structure on the same piers alongside a railroad structure. In the days of horse-drawn vehicles there was the risk of the frightened horses running away on such a bridge, with the clear possibility of farmers trying to get easy money by suing the railroad company for damages, so that such joint arrangement fell into disfavor with railroad men. Modern motor traffic changes the situation radically. But on the other hand the age of railroad bridge construction is passing. There is no likelihood that more railroad bridges of long span will be built for the enormous loads of present-day freight service. Therefore bridges of long span will in future be found almost exclusively in highway service.

Toll bridges of former days have in many instances had a varied history, and most of them ultimately passed to public ownership. An illustration of such history is found in the Smithfield Street Bridge, crossing the Monongahela River in Pittsburgh. The first bridge built there was a toll bridge. It was erected in the pioneer days of 1813, a covered wooden structure of eight spans each 188 ft. long—a famous work in its day. This wooden bridge burned down in 1843, and was replaced in 1845 by John A. Roebling, who here built his first road bridge with his form of wire cables. The traffic over it grew to be the heaviest over any toll-road bridge in the world. At modest rates it took in $60,000 a year in tolls, for its time an unheard-of income in the toll-bridge field. But in 1882 it had to be re-built by the writer with lenticular trusses of 360 ft. span, proportioned for the heaviest wagon-loads. This was the first steel bridge for highways. But not many years later came the necessity for widening the bridge to accommodate heavy electric street cars, and since then there have come the concentrated loads of heavy motor trucks, so that a new and still stronger bridge is needed. The bridge was bought by the city years ago and made free of tolls. When it is rebuilt the work will therefore be done with taxpayers' money.

This development is typical of the history of many old toll bridges, in which the initiative was furnished by enterprising private capital, but the structure later went

CAPTAIN EADS' ARCH BRIDGE OVER THE MISSISSIPPI AT ST. LOUIS

into final public ownership—when public wealth and credit had grown sufficiently to afford it.

A Financing System for Today—At the present time it seems probable that the financing system most likely to endure is one which will retire the cost out of earnings

as rapidly as possible. This tendency will hold regardless of whether the capital has been raised through a corporation, through a governmental agency like the Port Authority in New York City, or through special public commissions such as built the Delaware River bridge in Philadelphia and the Holland Tunnel in New York. It is the present demand that a toll bridge shall not remain a profit-making investment of private capital indefinitely.

Repeatedly the complaint has been expressed that a highway toll-bridge tends to take a profit on the entire road system. But here again it is necessary to distinguish and recognize the proportion of cost of the toll-structure in the entire cost of the connecting road system and bridge. It is only fair that the toll collected from traffic passing over the bridge should be adjusted in proportion to such relative cost of bridge and connecting road.

3. *Some Modern Conditions Affecting Bridges*

HAVE we developed so greatly in bridge building that the present is a definitely new epoch in the art? There are those who believe that the progress of bridge construction has been greater in the last ten to fifteen years than in former periods. They point to the larger number of long spans in these highway bridges, and suggest that engineering skill is greater in proportion. But this would hardly be fair to the bridge engineers of thirty to fifty years ago.

The men of those days had to invent designs to meet severe demands. It was necessary that bridge parts be manufactured rapidly, hundreds or even thousands of miles away from the bridge location. Their details had to be so arranged that the erection of long spans could be done in the shortest possible time. Because such demands had to be met and were met, American bridge engineers and bridge constructors became the most resourceful and skilled in the world, in the rapid erection of heavy railroad structures.

At the present time the large amount of long-span highway bridge construction in the United States is being carried out as routine, made so by the inventiveness of the past. The very quantity of his large-size work renders it commonplace. Abroad, conditions are different. Any large bridge structure requires much longer time in planning and preparation before it is begun. A recent instance was a competition for a highway bridge at Cologne, in which not less than 26 designs were submitted. The accepted plan represent the longest-span bridge on the European continent, a span of 1,000 ft. On this side of the water we have at least four bridges with spans of 1,000 to 1,600 ft. under construction, not including the Fort Lee bridge over the Hudson River, which will have a 3,500-ft. span.

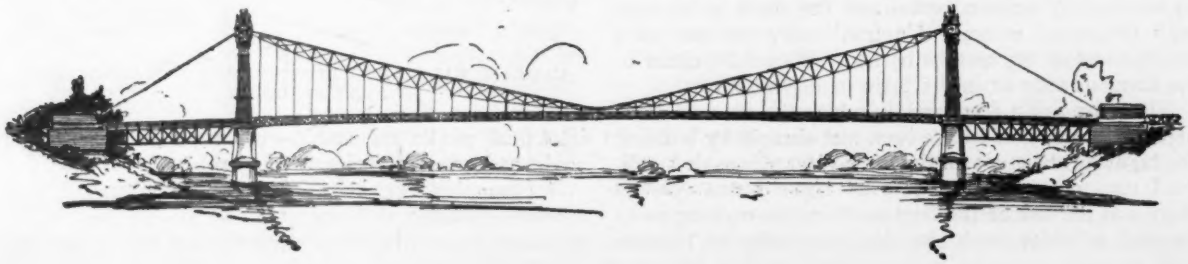
Bridge Permanence—On the problem of preserving the bridge against deterioration we may set it down as a general truth that with the present skill in scientific design, with our ability to determine the stresses for all conditions and combinations of loading and for the most violent wind-pressures from tornados, we can make sure of having safe structures which will last indefinitely, *provided the material is protected against corrosion.*

But to assure truly effective protection of the material requires as much skill on the part of the engineer as the determination of the stresses themselves. This fact received serious emphasis on the completion of the Firth of Forth bridge in Scotland 35 years ago, when its engineer, Sir Benjamin Baker, informed its owners that the bridge would require thenceforth forever a force of thirty to sixty painters to clean and paint the metal, beginning at one end of the mile-long steel structure and continuing to the other end for some five years, then going back immediately to repeat the operation. The steel towers in particular required special care. Without it the iron feet of that colossus would veritably be changed to feet of clay in a comparatively few years.

No cheaper and more effective way has yet been found to protect iron and steel against corrosion than systematic cleaning and painting except where it is possible to bury them in waterproof, solid concrete masonry. This has special reference to the protection of the anchorages of our giant suspension bridges. The first practice of carrying the anchor-chains down to their roots in open anchor-shafts has proved to be a source of danger. In American bridges this method of anchor-construction was never used, but instead from the first the practice was to enclose the anchor-chains solidly in concrete. All our big suspension bridges are absolutely safe in that regard.

We have also learned from costly experience that the floors of steel and iron bridges should, wherever practicable, be encased in concrete to preserve them against corrosion. In the first stages of long-span bridges, particularly for highways, the floors were built of wood, to save weight, with the expectation that when worn out they could readily be replaced. Such was the plan in the big suspension bridges over the East River. The mistake has been recognized and floor construction is being changed gradually to one safe against corrosion and excessive wear.

We have learned, therefore, to recognize that systematic and skilled maintenance after a bridge is completed is of as much importance as is skill in the design, fabrication, execution, and erection of the structure itself. Should the time come when the communities owning great metal bridges become smaller in population and wealth and neglect their proper maintenance, then their deterioration will begin. Their replacement will probably be impossible because there will then be no cheap iron or steel. Bridges of stone and concrete will last with very little attention. They should be preferred for permanence wherever the cost of them appears to be justified. But even concrete and stone bridges will not last forever in our climate.



SOME LEADING PROJECTS OF 1927 CONSTRUCTION

A representative collection of outstanding jobs upon which active work was carried on during the year just closed

Above: **Preliminary construction on the Coolidge dam, a "multiple dome" structure for irrigation in Arizona**

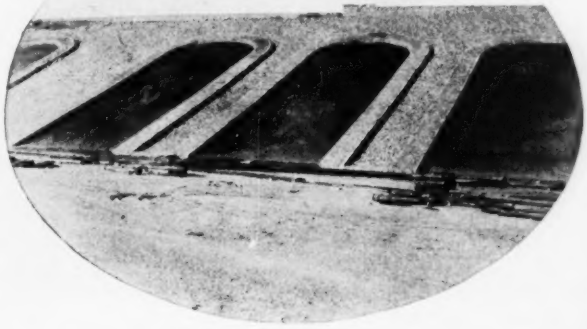
Below: **Cantilever truss bridge connecting New Jersey and New York, known as Outerbridge Crossing**

Above: Installing one of the lock gates in the Welland Ship Canal which connects Lake Erie and Lake Ontario in Canada.

Throwing up grade in construction of Central Highway in Cuba

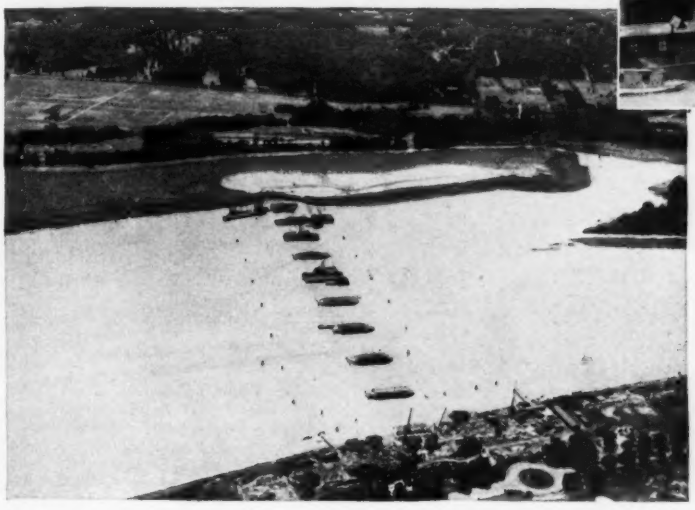
Right: Machine room and finishing room of modern paper mill recently constructed at Monroe, La.

Bottom (both pages): Lake Pleasant dam on Augua Fria River near Phoenix, Ariz. Combined irrigation and power multiple-arch structure 2,145 ft. long.



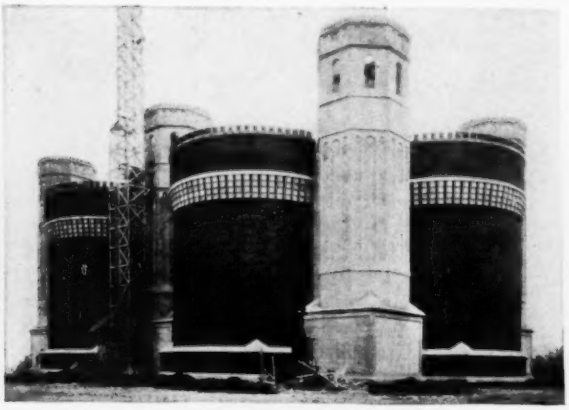
Landscape treatment of Wanaque Dam, North Jersey District Water Supply Commission

Above: New Engineering Building in Chicago. This 23-story office building will house the Western Society of Engineers on the top floor.

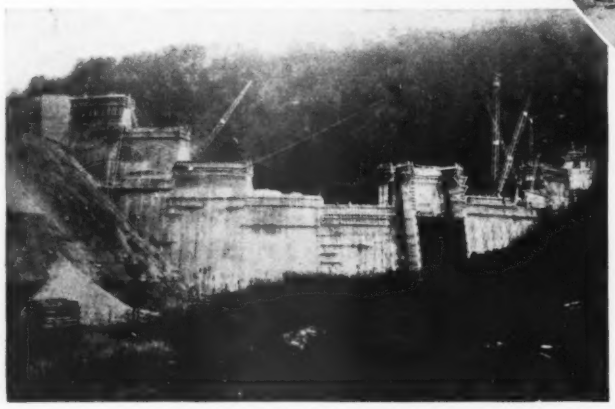


Left: Airplane view of piers for Arlington Memorial bridge across the Potomac River at Washington, D. C.

Bottom: Lake Pleasant dam on Agua Fria River near Phoenix, Ariz.

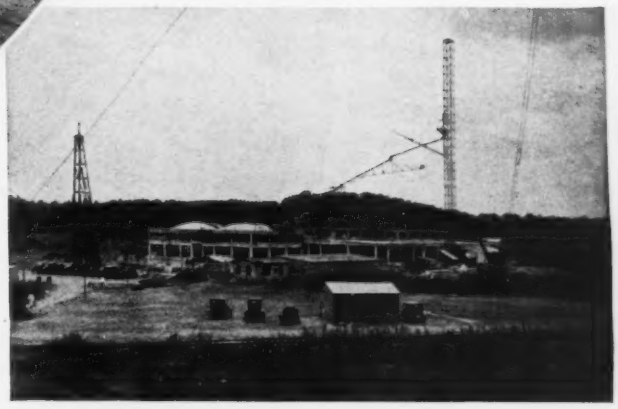


Top Left: Site of Owyhee dam on Owyhee River in Oregon. Structure to be used for storage of irrigation waters will be 360 ft. from foundation to parapet. *Top Right:* Mount Airy reservoir at Cincinnati with total storage capacity of 8.5 m.g. afforded in 14 tanks.



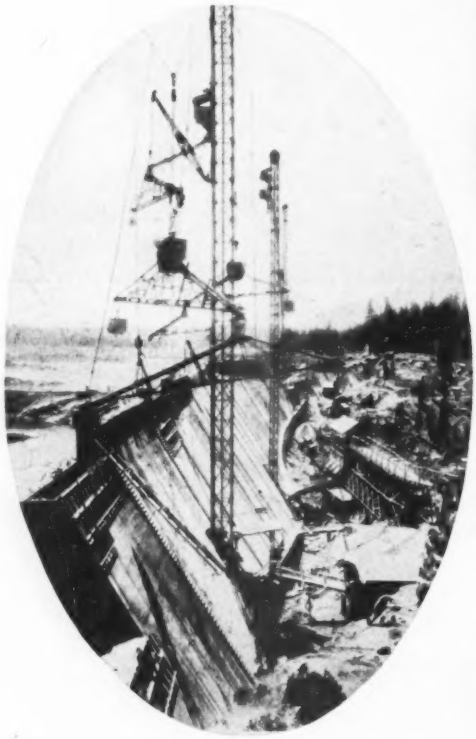
Above: Line changes near Yale, Colo., on Denver & Rio Grande Western. *Left:* Concrete arch dam across Caneadea Creek, Caneadea, N. Y., for Rochester Gas & Electric Corporation. Structure to be faced with brick. *Below:* Railroad and highway bridge across Kennebec River at Bath, Me.

Top Left: Grove St. Pier, Oakland, Calif. Part of $10,000,000 harbor development. *Top Right:* Horse Mesa dam on Salt River, Arizona. Structure is 306 ft. high above lowest point in foundation. Combination irrigation and power dam. *Left:* First train over Chesapeake & Hocking's new line from Gregg to Columbus, Ohio.

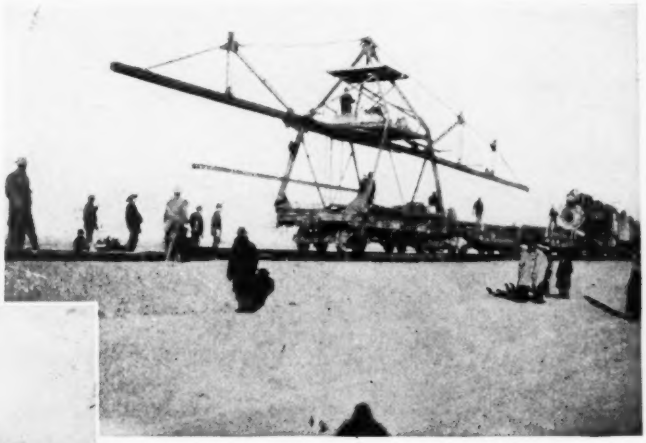


Right: Filtration plant of St. Louis water system for treatment of new supply from Missouri River. *Below:* Concrete pile bridge 4.72 miles long across Lake Pontchartrain. Louisiana, constructed by a private company as a new east highway approach to New Orleans.

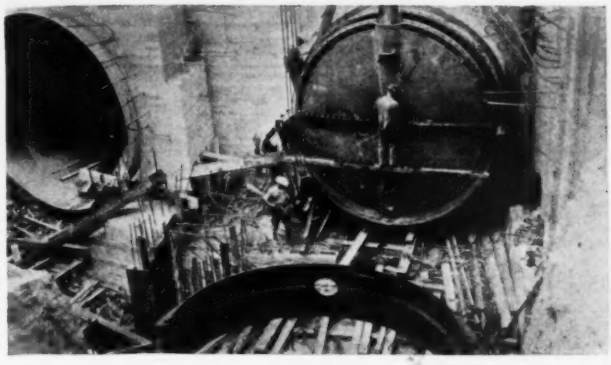
Below: Shaver dam of Southern California Edison Co. on Big Creek. Gravity structure 195 ft. high and crest length of 2,222 ft.



Above: Kittitas main canal on Yakima reclamation project in Washington. *Below:* Tracklaying on Santa Fé's extension from Manter, Kan., to Springfield, Colo.

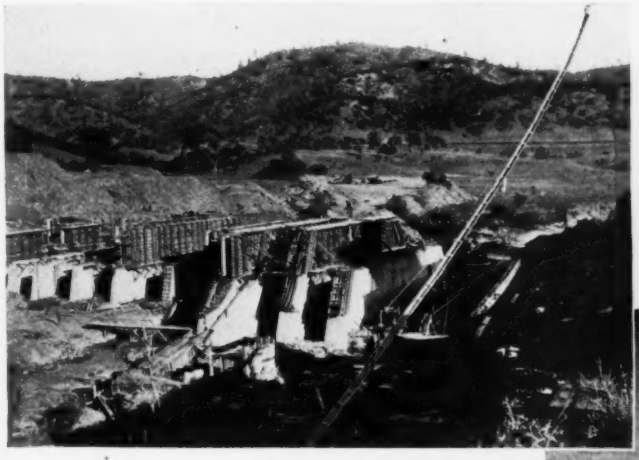


Left: Inter-City bridge across Mississippi, 1,521 ft. long and on new highway between St. Paul and Minneapolis. *Below* (both pages): Completed portion Alabama State Docks Commission's harbor work at Mobile.

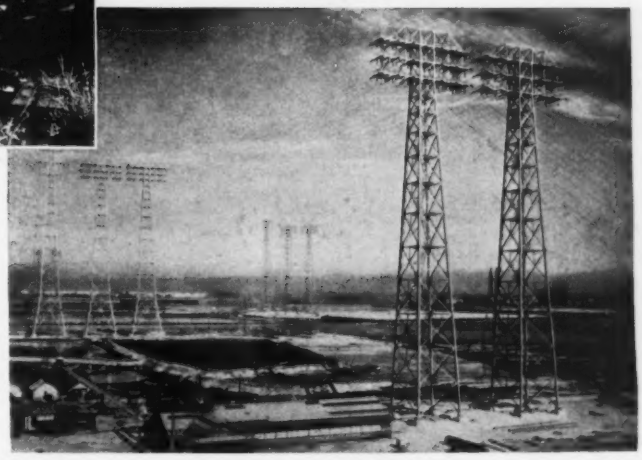


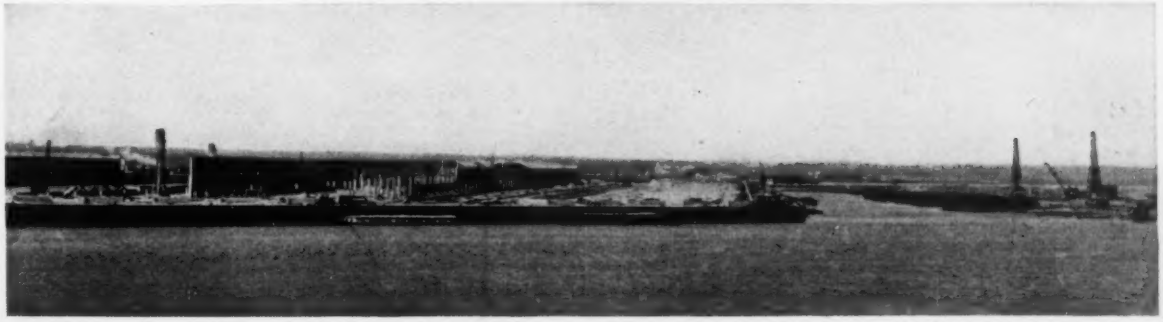
Above: Installing 14-ft. butterfly valve on Lake Chelan water-power project in State of Washington. *Below:* Stony Gorge dam on the Orland reclamation project in California.

Below: West portal of six-mile railroad tunnel under James Peak, Colorado



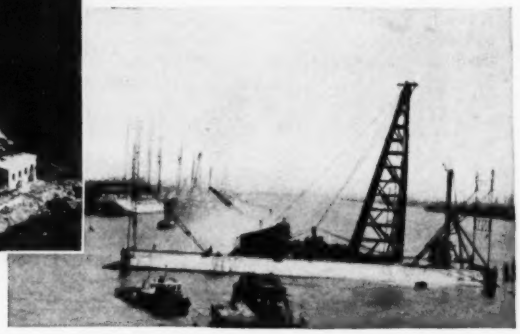
Right: Double line of 260-ft. steel towers, each of which carries six 60,000-volt circuits from Long Beach steam plant of Southern California Edison Co. *Below:* Completed portion Alabama State Docks Commission's harbor work at Mobile.

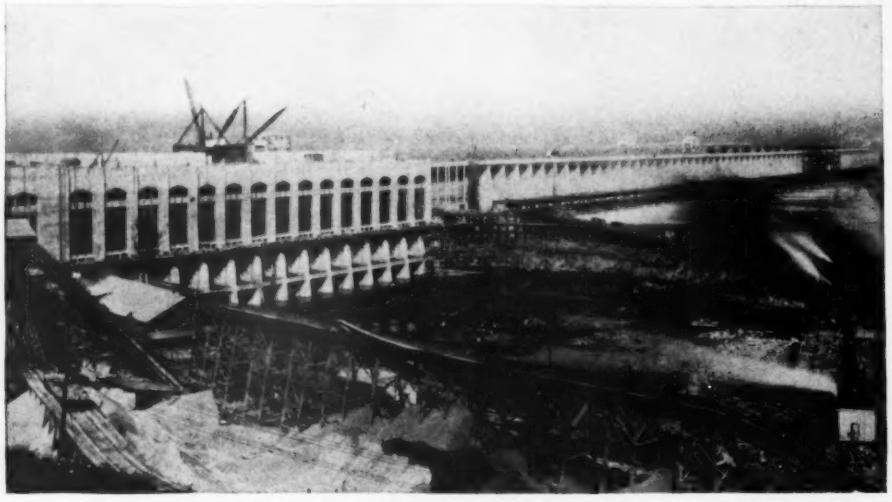




Right: Bucks Creek power house and penstock in Feather River Canyon, California. Static head 2,259 ft. *Below:* Twenty-three-foot pressure tunnel of St. John River Power Co. at Grand Falls.

Below: One of 12 segments of Oakland, Calif., Estuary Tube ready for sinking. Each is 203 ft. long and 37 ft. outside diameter.





Left: Dam and powerhouse of the Philadelphia Electric Co. across the Susquehanna at Conowingo, Pa., where 378,000 hp. will be developed according to present contracts with possible addition of 216,000 hp.

New Mississippi River bridge built by Santa Fé Railroad at Fort Madison, Iowa; upper deck leased for highway crossing.

Status of the
MAJOR ENGINEERING PROJECTS

Brief statements of the progress made to date on the more important civil engineering developments in the United States and Canada which are either under construction or to be started during the current year.

Diablo Dam, Skagit Project

In September last a contract for $2,263,000 was awarded for the construction of Diablo dam, Skagit Project, a unit in the hydro-electric development being carried out by the city of Seattle about 100 miles northeast of the city on the Skagit River. This dam will be a constant angle arch, 400 ft. high, developing a 90,000-acre-ft. reservoir that at first will store water for the Gorge power house six miles below; later, a power house is to be built at Diablo dam. The length of the arch proper will be 775 ft. and the total length, including spillways and tangents, 1,100 ft. The city has extended its Skagit railroad from the Great Northern Ry. to Diablo dam site, the line now being 32 miles long. Contract calls for completion of the dam in Sept., 1929.

Mokelumne Water Supply

Progress has been continuous on the project for storing water on the Mokelumne River in California and delivering it through a 95-mile aqueduct to the cities on the east side of San Francisco Bay. The aqueduct consists of a pipe 65 in. in diameter which will be under a head of about 500 ft. in the lower levels. Longitudinal seams in the pipe sections are electrically welded, the metal thickness ranging up to one-half inch. Early in December, 82 per cent of the aqueduct was in place and its final completion is expected some time in 1928. In the outlet tunnel from Pardee reservoir, 2.2 miles long, which was started in July, headings had been advanced a total of 1,900 ft. on Dec. 15. Both this tunnel and the Claremont tunnel, 3.4 miles long at the lower end of the line, are to be completed by the middle of 1929. Following a condemnation suit, work at Pardee dam began last July.

Voters of the district recently approved a bond issue of $26,000,000 for the purchase or construction of a distributing system by which this water can be delivered to the ultimate consumers.

Oakland Estuary Tube

A tube, 4,436 ft. long, is being built by trench method for street traffic under the estuary between Oakland and Alameda, Calif. All twelve of the 203 x 37-ft. segments in the precast portion of the tube have been successfully placed. On Dec. 15 all but two of the thirteen underwater joints had been poured and seven segments had been connected and made accessible on the inside, six on the Alameda end and one on the Oakland end. Other segments are being opened up as rapidly as the trench is backfilled. Meantime in the segments opened up the road slab is being finished, ceiling, sidewalks and conduits placed. Work is now under way on portal structures and ventilating equipment with expectation of opening the tube for service about May, 1928.

Los Angeles Flood Control

The greatest construction activity since the formation of the Los Angeles County Flood Control district marked the year 1927. The district now has 31 construction crews of its own at work, 14 contracts actively under way and 13 survey crews in the field. Although a start on the San Gabriel dam, the largest single item in the construction program, is still delayed by legal complications, a railroad to the site has been completed, camps constructed and other preliminary work done. Pacoima dam, an arched structure that will have the record height of 365 ft. above the stream bed, is to be completed by May of this year. The status of other dam projects is as follows: Big Santa Anita dam completed in May, 1927; Sawpit dam completed in June, 1927; Puddingstone earth-filled dam completed in December, 1927. In addition to important work related thereto the district has completed five dams to date and has protected 120 miles of stream channel. Two dam contracts have just been awarded, namely, for Big Dalton dam, a multiple arch dam 140 ft. above stream bed, to contain 40,000 cu.yd. of concrete, and Thompson Creek dam, a gravel structure with a height of about 100 ft., that is to be completed in three months.

Bridge River Power Project, B. C.

Construction is well under way on a 2½-mile tunnel, 13 ft. in diameter, which is the first step in the Bridge River hydro-electric project, B. C., built by the British Columbia Electric Railway Co. Contract for this tunnel was awarded in October and preliminary work had been finished by the first of the year. A total of 520,000 kw. is to be developed ultimately on this project although the first installation will be for only 40,000 kw. The contract calls for completion of the tunnel by August, 1930.

Hetch Hetchy Water Project

The city of San Francisco is building the Hetch Hetchy project to bring in a water supply from the headwaters of the Tuolumne River, 168 miles away. Since completion of the storage reservoir and 18 miles of tunnels in the mountain division, power has been generated in the Moccasin Creek plant yielding a revenue of approximately $2,000,000 per annum. During 1927 work has been concentrated on the 16 miles of 13 x 14-ft. tunnel in the foothill division, all but 2½ miles of which had been driven up to Dec. 15. About 37 per cent of this tunnel will be lined with concrete. In addition to the unfinished work in the foothill tunnel, the uncompleted gap on the Hetch Hetchy aqueduct includes 45 miles of steel pipe to be built across the San Joaquin Valley and 30½ miles of tunnel to be built through the Coast Range Mountains. This work should take about four years.

Colorado River Aqueduct

For years Los Angeles has been studying plans for bringing a water supply to the city from the Colorado River, 260 miles away. In 1927 there were completed field studies that had been under way four years, covering 18,000 sq. miles of the desert country that would be traversed by the proposed aqueduct. Cost estimates based on these data are now being compiled and a report with recommendations covering the scheme as a whole is to be submitted soon by the chief engineer of the department of water and power to the city's board of water and power commissioners.

New Cascade Railroad Tunnel

The 7.77-mile tunnel being driven for the Great Northern Railway in the Cascade Mountains, Washington, is still expected to be completed Nov. 30, 1928, the scheduled date, despite adverse ground conditions met during 1927 and a large inflow of water. Enlargement operations were in progress all year. On Dec. 1, 1927, there remained to be driven 5,329 ft. between the two pioneer headings that are approaching each other from opposite portals and, in the main tunnel, 17,777 ft. remained to be enlarged. Concrete

lining started at the west and east portals in May and July, respectively, and the best month's lining record was 1,425 ft. Total length lined on Dec. 1, 1927, 12,847 ft.

The Big Creek Power Project

On the Big Creek project of the Southern California Edison Company about $42,000,000 has been expended during the year on four major divisions as follows: (1) The Mono-Bear siphon which was brought to completion early in November conveys water from Mono and Bear Creeks across the canyon of the South Fork of the San Joaquin River to an adit of the Florence Lake tunnel which leads to Huntington Lake. This siphon which has a head of 780 ft. at the lowest point, required 13,805 ft. of pipe ranging from 75 to 102 in. in diameter and is fed by two tunnels; from Mono Creek the water is brought to the siphon by 3,933 ft. of 8 x 9-ft. tunnel and 4,533 ft. of 92-in. pipe and from Bear Creek by 7,866 ft. of 7 x 7- and 8 x 9-ft. tunnel. (2) A combination conduit and tunnel consisting of 3,163 ft. of steel pipe, 8 to 10 ft. in diameter, and 4.8 miles of 14 x 13-ft. tunnel connecting Huntington and Shaver Lakes was completed during the year. At Shaver Lake a concrete gravity section dam 2,222 ft. long and 195 ft. high was completed in September. (3) Power house 2-A with an initial capacity of 107,200 hp., to operate under a head of 2,420 ft. (static) is now under construction and is to be completed in July, 1928. (4) Work on the third 220,000-volt transmission line—the Vincent line—has been actively carried on throughout the year.

Moffat Tunnel

For this 6-mile tunnel through the shoulder of James Peak, in Colorado, piercing the Continental Divide at El. 9,200 ft., the excavation of the main or railroad tunnel was completed Dec. 10, while the last 5-ton steel set of lining was placed the same day. There remained 5,000 cu.yd. of concrete lining which was being placed by three concreting guns. When this is completed the track will be laid, with 110-lb. rails on treated red-oak ties, and it is expected to run the first train before the end of January. The tunnel has been leased to the Denver & Salt Lake Railway, and as this road decided to use steam locomotives a special study has been made for the ventilating plant and conditions. Although the tunnel is intended as part of a new railway route through Denver to Salt Lake and the Pacific Coast it will serve only for local traffic until some railway connections or extensions are built, since the Denver & Salt Lake Railway ends about 175 miles beyond the tunnel.

Owyhee and Other Reclamation Dams

The Owyhee reclamation project for the irrigation of 124,000 acres in Oregon and Idaho is to have a dam 360 ft. high in the canyon section of the Owyhee river about 20 miles from its mouth. Bids for the construction of the dam will be asked for early in 1928. Contract for the 22 miles of railroad from near Adrian, Ore., to the dam site was let in November at a price of $345,301.

Gibson dam, Montana, to furnish a supplemental supply for 90,000 acres of the Sun River project, is under construction. It will be of massive concrete-arch type 179 ft. high, costing $1,566,240. It is expected that the dam will be completed in the summer of 1929.

Stony Gorge dam to form a reservoir for a supplemental supply to 20,000 acres now under irrigation in the Orland project in California is about 60 per cent completed and will be finished in the latter part of 1928. The dam is of the buttressed type with a reinforced concrete slab, 120 ft. high, to cost $518,904.

Echo dam for the storage of water for the Salt Lake Basin irrigation project is to be an earthen structure of clay, sand and gravel, sprinkled and rolled. It will be 125 ft. high and 1,800 ft. long, containing approximately 1,700,000 cu.yd. of material. Contract for the work has been let for $1,125,098, and the structure will be completed early in 1930. Work on the relocation of railroads and highways in the reservoir site was begun in November and will be completed by January, 1929.

Deadwood dam in Idaho will be put under construction early in the spring. It will be a concrete arch 160 ft. high forming a reservoir of 150,000 acre-ft. capacity for the Payette division of the Boise irrigation project.

Kittatas and Vale Reclamation Projects

Construction of the Kittitas division of the Yakima project in Washington is actively in progress. Existing contracts cover 26 miles of the Kittitas main canal, one mile of the South Branch canal and 11 miles of the North Branch canal, with canal lining and structures. Bids are about to be asked for the construction of a small diversion dam and ¾ mi. of main canal. A total of $9,000,000 will be spent for the construction of the dam and canal system to irrigate 70,000 acres.

Contracts have been awarded for building 9 miles of the main canal of the Vale project in Oregon, including canal excavations, concrete lining and structures. Construction by force account, of a drainage system for the Warm Springs Irrigation District on this project is in progress and will be completed about July 1, 1928. An additional 12 miles of main canal construction will be advertised in a few weeks and about June, 1928 it is planned to ask for bids for the construction of a diversion dam across Malheur river and also 3 miles of main canal, about half of which will be tunnel work. The estimated cost of the Vale project is $3,600,000, and the irrigable area is 32,000 acres.

San Francisco Bay Bridge

After lengthy hearings late in 1926 by the San Francisco Supervisors on various private franchise applications for a toll highway bridge to the east bay cities, the board in 1927 decided to select a site and fix general features of the project before deciding on a franchise or on public construction. To this end it appointed a board of engineers, which recommended as best a location terminating in the city at Rincon Hill, second choice Hunters Point, and third choice Telegraph Hill—Goat Island. Application was then made to the War Department for approval of clearances for a bridge at the Rincon Hill site; the application was denied on the ground of objections by the Navy Department. The city has now carried the question to Congress.

Brazos River Diversion

A feature in port and harbor developments in Texas is the diversion of the Brazos River for the benefit of the port of Freeport, Tex. The bar at the mouth of the river is shoaled with every flood, and in view of the impossibility of maintaining a navigable channel across the bar, the U. S. Engineers in 1923 recommended that this project should be abandoned. Further examination was made, however, and Congress in 1925 appropriated $500,000 for a diversion channel as proposed by a board of engineers. At the same time Brazoria County voted a bond issue of $1,000,000 and a navigation district was created. A dam is to be built just above the city and a diversion channel excavated to carry the river to a new outlet on the coast. Then the old river channel below the city, for about 12 miles, will become an arm of the Gulf of Mexico, with 25 ft. of water for navigation and providing for wharves, docks and waterfront industries. The diversion channel will be about six miles long, having a bottom width of 450 ft. at its upper end, adjacent to the city, and then 250 ft., with the bottom 12½ ft. below mean water level. Contracts are to be let early in 1928 by the U. S. Engineer Office for dredging, and by the District for the bridge and other work.

Houston Port Developments

Public and private improvements at this Texas port, 50 miles inland from the Gulf coast, have been active during 1927. The ship channel is now 30 ft. deep, but the River

and Harbor Act of 1927 provided for a survey to give 32 ft. of water over a width of 250 ft. for the 25 miles to Galveston Bay and 500 ft. through the bay to the open sea. A 6½-mile extension of the channel for barges and light draft vessels reaches the heart of the city, and it is proposed to enlarge two miles of this for a 30-ft. channel 150 ft. wide, while the remainder would be 10 ft. deep and 60 ft. wide.

A concrete pile and deck wharf 500 ft. long is being built as an extension of the 480-ft. wharf served by the 1,000,000-bushel public grain elevator built in 1926. Another wharf of similar design, 460 ft. long, is being built. About ten miles of track have been added to the lines and yards of the Public Belt Railway. A large amount of road and bridge work is being done in the ship-channel district by the city and county, including the 6-mile Navigation Boulevard, 120 ft. wide with two 30-ft. brick roadways.

Alabama State Docks

The construction of an ocean terminal at Mobile by the State of Alabama has progressed rapidly during the year. Pier 1, which comprises 2,400 ft. of apron wharf, 300,000 sq.ft. of storage, and 207,000 sq.ft. in cotton warehouse, has been completed and is in operation. Construction all concrete and steel. The concrete and steel shipside warehouses on Pier 2, comprising about 14 acres (the pier being 1,600 ft. long and 560 ft. wide), are about half finished and should be completed by May 1. The slip between Piers 1 and 2, 1,600 x 350 ft., is completed. Concrete apron wharf for one side of Pier 3 should be completed by May 1, 1928, it being about two-thirds completed now. All railroad yards, interchange and classification, are completed and in operation. A material handling plant which will transfer coal from cars to ship or to storage at a maximum rate of 600 tons per hour and from ship to storage or cars at practically the same rate, should be completed by May 1, 1928.

St. Louis Water-Works Extension

The new water supply for St. Louis, Mo., to be taken from the Missouri River to supplement the existing supply from the Mississippi, has been completed in many of its parts and nearly all the rest are well along. It is hoped that the entire new plant will be in operation early in 1929. Completed portions include the intake and 87,000 ft. of 62-in. riveted steel pipe line leading to the Stacy Park covered reservoir. This reservoir is nearly completed. It is 600 x 800 ft. in plan and has a capacity of 100 m.g. The filtration plant and accessories are well along, as also the pump and boiler houses. It is expected that the turbine centrifugal pumps will be delivered early in 1928. These include a 100-m.g.d. and two 50-m.g.d. low service pumps, besides 30-m.g.d. high service pumps.

Ohio River Locks and Dams

Improving the Ohio River for navigation by providing a minimum channel depth of 9 ft. for its entire length of 968 miles continued throughout the year by the Corps of Engineers. The work consists of construction of two fixed and forty-eight movable dams with navigation locks having general net dimensions of 110 x 600 ft. at each dam. Navigable passes vary in width from 600 to 1,248 ft. and are closed by wickets of the Chanoine type. The second of the fixed dams is located at Deadmans Island, about 13 miles below Pittsburgh, and is under construction. This dam when completed will take the place of present dams Nos. 3 and 4. All of the dams (not including the Deadmans Island dam) between Pittsburgh and mouth of the Wabash River have been completed. These dams make available 839 miles of continuous navigation on this river. The new dam at Louisville, having a maximum head of 37 ft., has been completed in connection with the development of electric power. Below the mouth of the Wabash River on a stretch of 129 miles, no dams have been completed, four are under construction, and one has not been started. Total cost of the work estimated at $105,000,000. To date, about $89,000,000 has been spent.

Illinois Waterway

A waterway of 63 miles, from the Chicago drainage canal at Lockport, Ill., to the Illinois River at Starved Rock, is being built by the State of Illinois as a part of the proposed barge waterway connecting Lake Michigan with the Mississippi River. Its channel is 200 ft. wide, with 9-ft. depth of water and with five locks 110 x 600 ft., the first having the unusual lift of 41 ft. The Marseilles and Lockport locks are completed, and the Starved Rock lock and dam are 70 per cent completed. The Brandon Road lock, dam and pool are under construction by State forces. The remaining lock and dam and the Marseilles diversion canal are to be placed under construction in 1928. Contracts for valves and miter gates for the Lockport and Marseilles locks were completed in 1927. It is expected that the waterway will be completed in 1930. Provision for a 9-ft. channel in the Illinois River from the end of the waterway at Starved Rock to the Mississippi River was authorized by Congress in 1927.

Chicago Sanitary District

The activated-sludge plant of the Sanitary District of Chicago, known as the North Side sewage-works, was about 89 per cent completed at the close of 1927. It will serve about 830,000 persons and is estimated to cost $17,500,000. The force main to convey excess sludge from the North Side to the West Side works is under construction. It is of 14-in. centrifugal cast iron pipe, 18 miles long. The West Side plant, which will serve 1,850,000 population and is estimated to cost $19,500,000, has about a third of the tanks completed. Since the granting of the permit for diversion, from Lake Michigan by the Secretary of War on March 3, 1925, some $36,000,000 has been spent on main sewers, pumping stations, and sewage-works, of which $27,000,000 has been for sewage treatment. The cost of carrying out the entire program may be as much as $155,000,000, of which $61,000,000 has already been spent. It is expected that the North Side works will go into service during the summer of 1928 and the first unit of the West Side Imhoff tanks shortly afterwards.

Chicago Freight Terminal; C. & N. W. Ry.

Probably the largest freight transfer station in the world was put in operation in October by the Chicago & Northwestern Ry. as part of its great terminal freight yard now under construction at Proviso, about 12 miles from Chicago. This transfer station is a one-story building 1,420 x 626 ft., having a capacity of about 700 cars. The freight yard, which will be the destination and starting point of all road freight trains, is peculiar in being L-shaped, as it serves main lines extending northward and westward. There will be two switching humps. At its east end the yard is connected with one of the Chicago belt lines, giving interchange facilities. The yards have a total length of about five miles and the total area for yards, transfer station, engine terminal and other facilities is about 1,500 acres. The total cost is estimated at $16,000,000 and it is expected to have the entire layout completed in 1930.

Cincinnati Rapid Transit

A municipal rapid-transit subway, practically completed but still unused, is a feature in the local transportation system at Cincinnati, Ohio, and there is now prospect of its being utilized as part of a unified system. This subway, completed a few years ago at a cost of $6,100,000 provided by a bond issue, was intended to bring several interurban lines into the center of the city, but since the project was started most of these lines have gone out of business, partly on account of the enormous development in automobile traffic. No funds were available for equipment and operation by the city. To devise some way of deriving benefit from the investment, a study of the city's transportation system was made in 1927 by an engineering firm whose report will be a basis for possible operation of the subway under lease and

also a basis for an issue of bonds to complete the work. About $7,000,000 will be required for extensions to connect with street-car lines and $3,000,000 for equipment. Lease of operation to the street railway company is proposed, and if this lease is approved by referendum vote the necessary bond issues will be submitted for vote. Meanwhile the route over the subway (in the bed of an old canal) is being developed as a boulevard and parking.

Cleveland Sewage Works

The Imhoff tanks and trickling filters on the Cuyahoga River to serve 280,000 of the population of Cleveland, Ohio, are nearly completed. The plant is known as the Southerly sewage-works and with the two plants in use will treat the sewage of nearly all of Cleveland. Under the direction of the Cuyahoga County commissioners, studies have been completed for a sewerage and sewage disposal system for the westerly portion of Cuyahoga County, which has an area of 125 sq.mi. and is known as the Rocky River drainage area. Ultimately, the plans call for an activated-sludge plant on the lake front, from which the excess activated-sludge would be pumped 6 or 8 miles for disposal by digestion with the Imhoff sludge from the Cleveland Westerly plant. Meanwhile, three temporary treatment plants are proposed. The estimated cost for immediate construction is $3,500,000 and the ultimate total is $6,750,000. The Southerly works for Cleveland will cost about $3,600,000 not including land.

Cleveland Passenger Terminal

A union railroad terminal for the Nickel Plate, New York Central, and Big Four railroads, and a rapid transit terminal for local suburban lines, is being built by the Cleveland Union Terminals Co. adjoining the public square at Cleveland. Work on the east approach is well along and will be carried on during the winter. Work on the west approach is well advanced. Piers for the viaduct over the Cuyahoga River valley are about 75 per cent completed and contracts for the steel work have been let. Contracts for the smaller bridges also have been let. The Terminal Tower Building, a 52-story structure, is almost completed.

Detroit River Tunnels

Twin vehicular tunnels under the Detroit River between Detroit, Mich., and Windsor, Ont., similar in cross-section to the Holland Tunnel at New York except that the outside diameter is to be 30 ft. and the roadway 22 ft. Contract for the construction has been let and sub-bids are being called for the tunnel section between the land shafts, a total of 4,000 ft., including the 2,400-ft. mid-river section. The method of constructing the tunnel, whether by shield or other means has not been decided upon, bids being asked on the various methods.

Buffalo Central Terminal

A new passenger terminal being built for the city of Buffalo, N. Y., by the New York Central Railroad Company, consisting of a passenger station two miles east of the present station, a coach yard, power house and mail and express facilities, all occupying an area of 73 acres. The grading has been done, the track work is 25 per cent completed, the power house 80 per cent and the mail and express facilities 50 per cent. The foundations of the station are completed and 10 per cent of the steel work is erected.

Welland Ship Canal

Construction operations on the new ship canal which the Canadian Government is building between Lake Erie and Lake Ontario reached a peak in 1927, all sections being under active construction. The harbor work at Port Weller and locks 1, 2, and 3, with the intervening canal prism were completed except for service gates and lock operating equipment. The flight lock structure, comprising twin locks 4, 5, and 6, and single lock 7 is now about 94 per cent completed. The guard lock at Port Colborne, No. 8, is 90 per cent completed and the intermediate sections of the canal prism are from 35 to 96 per cent completed. Watertight embankments are about 50 per cent completed. The whole breakwater extension at Port Colborne is finished. Four 80-ft. rolling-lift bascule-type bridges were completed during the season as well as one 200-ft. vertical-lift bridge. Contracts for the construction of three more this winter have been let. The construction of one 200-ft. double-leaf bascule bridge is under way. Present progress indicates that the canal will be usable from Lake Erie to Lake Ontario by upper-lake freighters in the summer of 1930, and that some portions of the north end will be available for the diversion of present canal traffic in the summer of 1929. Total expenditures to date are $86,000,000 of the total estimated cost of $115,000,000.

St. Lawrence Waterway

The present proposal for improving the navigability of the St. Lawrence river consists in providing a navigation channel 25 ft. deep in the 183-mile section of river between Lake Ontario and Montreal with 9 locks and 25 miles of canal. The initial power development proposed is about 2,700,000 hp. and the ultimate 5,000,000 hp. The joint board of engineers submitted its report in November, 1926. Since then no official action has been taken by either country other than an interchange of correspondence which resulted from advances looking toward the start of negotiations made by the state department of the United States in April, 1927. At present, a bill is about to be presented to Congress making an appropriation for further detailed engineering studies.

Saluda Dam

A hydro-electric power development on the Saluda River near Columbia, S. C., being built by the Lexington Water Power Company, a subsidiary of the General Gas & Electric Corp. The major item of construction is an earth-fill dam approximately 8,000 ft. long and 208 ft. high. Contract for the construction of the dam was let in August. Estimated cost of the entire project, $21,000,000.

Conowingo Dam and Power House

A 4,800-ft. dam and power house being built near the mouth of the Susquehanna River by the Susquehanna Power Company, a subsidiary of the Philadelphia Electric Company. A total of 378,000 hp. in seven 54,000-hp. units is to be installed in the power house under the present contracts and provision is being made for four more similar units. Work was begun in May, 1926, and it is expected to bring the first units into service early in 1928. To date construction of dam and power house has been completed except for final closure of the spillway notches, and this has been in progress since October, 1927. Excavation of tailrace, clearing of reservoir and construction at the highway bridge on dam have been completed. Installation of water wheels and generators is making excellent progress.

Pennsylvania Terminal, Philadelphia

New terminal facilities are being built by the Pennsylvania R.R. at Philadelphia under an agreement made with the city in 1925. Plans call for a new main station at West Philadelphia to replace Broad St. station, removal of elevated railway from Schuylkill River to Broad St. station and its replacement by an underground railway to a suburban station just north of Broad St. station, opening up a new street from City Hall along the line of the present elevated railway across the river to the new station, the construction of a new office building and rearrangement of yards and tracks at West Philadelphia. Electrification of suburban lines still operated by steam is an essential feature of the plan, but is not specifically included in the agreement. At this time, work is in progress on four blocks of the subway and elevated work east of the Schuylkill River, and the first section of the office building is West Philadelphia is completed.

Philadelphia Subways

Work on the new subway in Philadelphia, in progress for something over three years, is well along toward completion north of the city hall on Broad St. Contracts for additional work on South Broad St. were let during the year. Deliveries of operating equipment began during the year but as yet no decision has been reached as to the method of operation.

Arlington Memorial Bridge

Pier construction on the Arlington Memorial Bridge over the Potomac River at Washington was nearly completed during 1927, and a contract has just been let for the construction of the reinforced-concrete barrel-arch superstructure. This bridge is noteworthy because of its very high cost for its size, due to costly stone facing and other architectural work.

Detroit Bridge

An international bridge across the Detroit River from Detroit to Windsor (Ont.) was put under construction last summer. Pier construction is at present actively in progress. The structure is to have a main span of 1,850 ft. and carry a single highway deck. It is being built by a private company and will be operated on tolls.

Mid-Hudson Bridge

The state highway bridge under construction across the Hudson River at Poughkeepsie is in the stage of active substructure work. The two main piers are being sunk by dredging, as open cylinders to depths of about 125 to 135 ft. The west pier is nearly completed. The east pier tipped over to an angle of about 40 deg. when sinking had just started after grounding the reinforced-concrete cylinder; righting operations have been in progress during the past four months. The bridge will be a suspension structure of 1,500 ft. span.

Mount Hope Bridge

After several years' negotiations for the construction of a bridge to connect the Island of Rhode Island with the main land between Portsmouth and Bristol, with both state and private projects in the field, a private toll bridge franchise was granted by the state legislature, and late in the year contracts were let. Pier foundation work is now under way. A suspension bridge with 1,200-ft. main span is to be built.

Fort Lee Bridge

In December, 1926, the War Department approved the clearances proposed by the Port of New York Authority for its highway suspension bridge of 3,500 ft. main span across the Hudson River between the upper part of New York City (at Fort Washington Point) and Fort Lee, N. J. Bonds for the initial half of the construction work were sold the same month. During 1927, after final restudy of the plans, contracts were let for the west main piers, for the rock cut of the west approach and anchorage tunnels, and for the cables, towers and suspended superstructure. The west tower foundation will consist of two separate piers, one for each tower leg. Each pier is being built in a steel sheet-pile cofferdam about 100 ft. square, excavated in the dry to rock (Newark sandstone), which lies at depth 45 to 70 ft. below water, sloping down toward the river. One of the piers has been carried up nearly to water level. The superstructure contract was let on alternate bidding for eyebar cable and wire cable designs; the lowest bid was on the latter. Contracts for the east (New York) pier foundation and anchorage are to be let soon.

Other Large Bridges

Superstructure erection continued on the Montreal South Shore bridge, the 1,200-ft. cantilever span bridge nearing completion.

Erection of the cantilever spans of the two Arthur Kill bridges of the Port of New York Authority was begun in summer and practically completed by the end of the year.

A steel arch bridge of 1,600 ft. span to be built by the Port Authority across the Kill Van Kull between Bayonne, N. J., and Staten Island reached the stage of approval of clearances by the War Department, and bonds to cover its cost have just been sold. Construction will begin actively in 1928.

North Station, Boston

Plans for a new North Station for the Boston & Maine Railroad were announced in November when a contract was let for the construction of the station and a coliseum in connection with it. The entire project includes, in addition, the construction of an office building and a hotel at a total cost of about $10,000,000.

Boston Metropolitan Water Project

On the $65,000,000 project for an additional water supply from the Swift and Ware Rivers for the Boston Metropolitan district six construction shafts 310 to 650 ft. deep have been sunk to tunnel grade and headings started on the easterly half of the 25-mile tunnel extending westerly from the existing Wachusett reservoir on the Nashua River. Near the close of 1927 bids were received for constructing the easterly half of the tunnel. To meet the growing water demands of the district prior to the completion of the Swift-Ware project $900,000 has been authorized to divert water to the existing system from several small tributaries of the Sudbury River. Some water was thus diverted on Nov. 15.

New York Water Supply Extensions

Approval was given by the Board of Estimate of plans for a new pressure tunnel, 17 ft. in diameter at the upper end and some 20 miles long, to supplement the one already in use for delivering water from the Catskill aqueduct system to the various parts of New York City. Studies for the tunnel are under way. Recommendations for an additional supply of 600 m.g.d from five New York tributaries of the Delaware River and 70 to 100 m.g.d. from Rondout Creek, a tributary of the Hudson, together with the diversion into the existing Catskills aqueduct system of water from some of the higher levels of the Croton system, were submitted by the Board of Water Supply of New York City in 1927, and a preliminary hearing on the project was held by the Board of Estimate on Dec. 15. A proposal to develop 150 m.g.d. from wells on Long Island for emergency use was also before the Board of Estimate at the close of the year.

New York Subways

Rapid progress was made on construction of the Eighth Ave. subway in New York City and a number of large contracts for other extensions were let during the year. Work has been started on the line from Church and Fulton Sts., Manhattan, to Cranberry, Furman and High Sts., Brooklyn, a project entailing the expenditure of more than $22,000,000. Another large project which was put under way is the 53rd St. tunnel under the East River, the contract price for the three sections of this work being around $24,000,000. After years of controversy over the advisability of its construction, the Nassau St. (Manhattan) loop, was let to contract late in the year. New contracts also were let for extensions in Queens and Brooklyn.

Mexican Irrigation

The National Irrigation Commission of Mexico has the following projects under construction: The Don Martin project lying in the states of Nuevo Leon and Coahuila, 165,000 acres of land, to be watered from a reservoir now being constructed on the Salado River to store about 48,000,000,000 cu.ft. of water. The Presa Cales project located in the state of Aguascalientes, containing about 50,000 acres of land. It is to be watered from a reservoir of 12,000,000,000 cu.ft. capacity formed by a concrete arch dam 230 ft. high. The Rio Mante project located in the State of Tamaulipas containing about 50,000 acres of land. Water for irrigating this land is to be taken directly from the Rio Mante by means of a canal and small diversion dam. The aggregate cost of the work will be about $15,000,000. It is being done under the direction of American engineers.

Statistics and Prospects of Construction

Another year of high production—1927 construction volume at maintained peak, but without cost inflation—Heavy construction exceeds previous year—Materials and labor conditions excellent—A sound credit position—The 1928 prospect favorable

ANOTHER remarkable year's record has been made by the construction industry. Its total transactions in dollars during 1927 were about equal to those of 1926, an unprecedented year; and after adjusting for a 1 per cent cost decline in 1927, the actual volume is slightly greater.

The 1927 Construction Volume

A grand total of $7,800,000,000 was invested in construction during the year. This is the same, within the limits of accuracy of the statistics, as the 1926 figure. Both figures exceed those of any prior year, as the following comparison brings out:

	Total Construction Value in Dollars	Value in Terms of 1913 Purchasing Power	Physical Volume (1913–100)
1913	$1,600,000,000	$1,600,000,000	100
1914	1,500,000,000	1,700,000,000	106
1915	1,600,000,000	1,700,000,000	106
1916	2,400,000,000	1,800,000,000	113
1917	2,600,000,000	1,400,000,000	88
1918	3,200,000,000	1,700,000,000	106
1919	3,400,000,000	1,700,000,000	106
1920	3,600,000,000	1,400,000,000	88
1921	3,500,000,000	2,000,000,000	125
1922	4,900,000,000	2,400,000,000	150
1923	5,400,000,000	2,500,000,000	151
1924	6,000,000,000	2,800,000,000	175
1925	7,500,000,000	3,600,000,000	225
1926	7,800,000,000	3,750,000,000	234
1927	7,800,000,000	3,780,000,000	236

In this table the second column, obtained by dividing the first column by the *Engineering News-Record* Cost Index, indicates the physical increase in construction. This column gives the value of contracts in terms of the 1913 construction dollar, and gives the true measure of increased work. The physical volume of construction remained practically the same from 1913 to 1921. But in 1922 came a big jump; the total value of contracts increased 44 per cent over that of 1921, encouraged by a 13 per cent price recession to a level 30 per cent under the 1920 peak. Each year since then the physical volume of construction has increased, as follows: (1923) 4 per cent, (1924) 17 per cent; (1925) 25 per cent; (1926) 4 per cent; (1927) 1 per cent. These are not startling increases, particularly in view of the tremendous shortage in residential building and public works that developed during the war. The aggregate fact is, however, that we are now doing twice as much construction per year as we did fourteen years ago—and at more than four times the cost.

Nature of Growth

Fig. 1 shows at the left percentages of the main classes of construction, and at the right the subdivision of heavy construction, which totaled 42 per cent of all construction. The significant fact with respect to the three major divisions is that *engineering construction exceeded the 1926 figure by 14 per cent.* This while residential building and other small work fell off 5 per cent. The total of engineering construction in 1927 was $3,254,000,000, comprising 61 per cent private work and 39 per cent public work.

Fig. 2 shows the progressive increase in construction during the last seven years. Each of its sub-groups shows a prosperous growth during this period and, while 1926 was a big year, all show further increase in 1927.

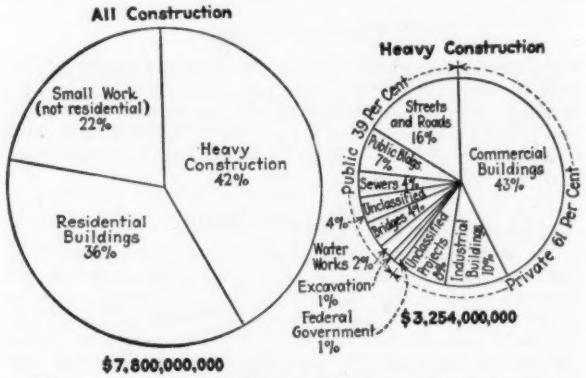


FIG. 1—TOTAL CONSTRUCTION AND ENGINEERING CONSTRUCTION SUBDIVIDED
(Engineering News-Record Statistics)

Under public works, waterworks dropped off. Bridges showed the greatest percentage gain. The year's contracts included such great structures as the Fort Lee bridge, the Mid-Hudson, Detroit and Mt. Hope bridges, and many other large projects. The largest thirty-six in the country total $84,000,000—or 42 per cent of the cost of the 572 bridge contracts reported. The increase in lump value of commercial and institutional buildings is 11 per

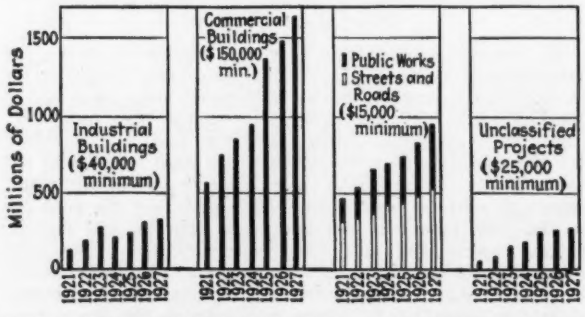


FIG. 2—SEVEN YEAR GROWTH OF HEAVY CONSTRUCTION
(Engineering News-Record Statistics)

cent compared with 8 per cent in 1926. Thus continues, though at a little slower rate, the modernization of business facilities.

Industrial building, or plant expansion, slightly exceeded the 1926 total, due to increased activity in the latter half of the year. Both 1926 and 1927 surpassed the previous high year, 1923. It appears that the machinery of production calls for continuous improvement.

The dozen largest contracts total $201,738,276, and are headed by a rayon plant in Tennessee. The others include a hydro-electric plant on the Saluda River, S. C.,

a gas pipe line in Texas, a passenger station in Buffalo, two New York subway contracts of $22,282,309 and $10,481,550, and similar important items. Mention must also be made of the unusual volume of pipe lines definitely planned in 1927. Only twenty-eight of these total 4,427 miles and will cost $120,000,000.

Geographical Distribution—Engineering construction activity is well distributed over the country. Referring to Fig. 3 it is seen that the only decrease is in New

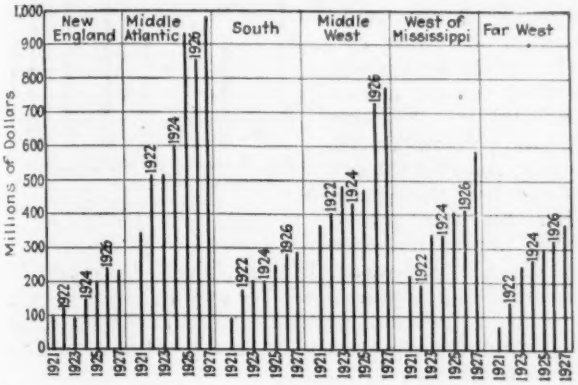


FIG. 3—GEOGRAPHICAL GROUPING OF CONSTRUCTION GROWTH
(Engineering News-Record Statistics)

England. This section as a whole was under the 1926 total awards, but public buildings and all classes of public works, except streets and roads, increased $7,163,000 or about 10 per cent, against a decrease of 11 per cent in private contracts, mainly in Massachusetts and Connecticut. All the other sections show increases, the greatest in the Middle Atlantic states and in the West. The percentage increase for the states west of the Mississippi reached 43 per cent, while that for the Middle Atlantic and Far West was 15 per cent. New York, New Jersey, Michigan, Texas, Tennessee and Missouri showed totals ranging from $106,000,000 to $36,000,000 larger than the preceding year.

Prices of Materials

Like wholesale commodity prices in general, the prices of construction materials have been declining. This downward movement, not a deflation movement as was that of 1920-1921, has gone on despite unprecedented and increasing demand. Doubtless this is due in part to technical progress, giving greater production at lower cost. However, the element of keen competition must not be overlooked, and the ability of credit to finance the output is probably a factor.

Declines in materials prices since a year ago average

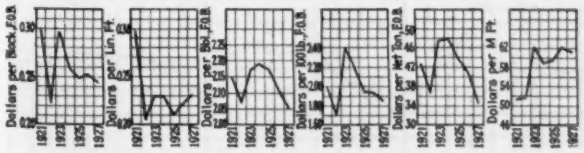


FIG. 4—TREND OF MATERIAL PRICES
(Engineering News-Record Statistics)
The figures show, left to right, Hollow Tile, New York District; Sewer Pipe, 6-in. New York, delivered; Cement, Chicago; Steel Shapes, Pittsburgh; Cast Iron Pipe, 6-in., Birmingham; Lumber, pine, New York.

the following percentages: steel shapes, 12; lumber, 11; cement, 3; brick, 6; paint stuffs, 15. The average decline for all is 10 per cent. Fig. 4 gives seven-year trends in some of the principal materials.

Steel prices were weak until November, when shapes advanced 5 cents per 100 lb., to the current level of $1.80—without increased demand. If steel quotations are partly artificial, coming demand from full-speed automobile production may make them wholly real.

Cement prices generally were steady throughout the year. Imports though considerably under those of 1926, are being watched, particularly in the Hudson Valley. In July an Eastern company reduced prices slightly to meet import quotations, but for the country as a whole foreign competition in cement does not exist.

Cast-iron pipe dropped $2 per ton, Birmingham, in October, followed by another drop of $2 in November, and a 50 cent drop in December. The slump is due to low demand—lower than is usual at this time. The 14 per cent drop in water-works contracts should be recalled in this connection. Here also imports of foreign material are a factor; in the first nine months of 1927 they increased 51 per cent over the same period of 1926.

Brick is more largely a local matter, as to prices, than are other materials. In the East imports had an important influence; these imports in the first quarter of 1927

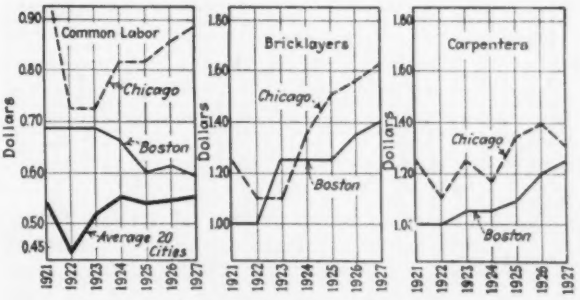


FIG. 5—CHANGES IN WAGE RATES
(Engineering News-Record Statistics)

amounted to 12 per cent of the shipments from yards in the New York district. Easier prices developed, and in general the general trend all over the country has been downward; yet there are points, such as Pittsburgh, Cleveland, and Kansas City, where prices are higher than a year ago. Declines in Atlanta and Dallas amounted to about 50c. per M. The greatest drop was in New York, from $17 to $14 at dock.

Employment and Wages

Last year brought only a few important strikes in the building trades. Except for a small strike of cement finishers and waterproofers in Boston, arising from a misinterpretation of an arbitration award, there were no real labor disputes in the industry. In fact, labor as a whole was in a stable and unusually peaceful condition, two or three industries excepted. The bituminous coal industry remains in a state of upheaval, and a decided wage reduction was made recently by the New England textile mills which has not contributed to good feeling in the labor field generally. But with a few exceptions of this kind the purchasing power of labor fluctuated far less than was the case some years ago.

Building Trades Wages—Wages of skilled building trades mechanics on Jan. 1 had advanced about 4 per cent over those of a year ago for the entire country, while common labor declined 1.4 per cent (from 55¾ cents per hour to 55). Scanning wage fluctuations in

twenty cities throughout the country there are found fourteen instances of definite increases, and no reductions. Ironworkers received increases averaging 12 cents an hour, in Baltimore, Dallas, Denver and Philadelphia. Other increases were as follows: *Carpenters*—Boston, from \$1.25 to \$1.37½; Dallas, \$1.21½ to \$1.25; Detroit, \$0.90@\$1.15 to \$1.25; *bricklayers*—Cleveland, \$1.50 to \$1.62½; Detroit, \$1.50 to \$1.56½; Pittsburgh, \$1.62½ to \$1.70; *hoisting engineers*—Cincinnati, \$1.31½ to \$1.37½; Cleveland, \$1.30 to \$1.37½; Denver, \$1.12½@\$1.18¾ to \$1.25@\$1.37½; *hodcarriers*—Cincinnati, \$0.95 to \$0.97½. On Jan. 1, 1927, there were thirty-two increases over the Jan. 1, 1925, levels to be noted for these four trades in these twenty cities. Fig. 4 compares annual average wages for three trades.

General Factors of the Situation

With this remarkable contrast of high and expanding volume of construction, and at the same time decreasing costs, the main factors of the situation are interesting. One of them, a general advance in industrial efficiency,

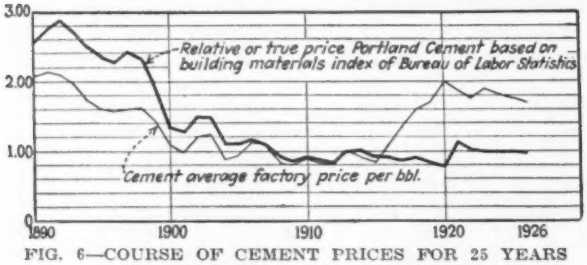


FIG. 6—COURSE OF CEMENT PRICES FOR 25 YEARS
(Source: Portland Cement Association)

is reflected in the 25-year plotting of cement prices, Fig. 6. It will be seen that there was a steady downward course of price, which means of production costs, from the beginning of the centrury to the time of the war. Since then, the general price trend has been about level, which in view of the increased labor and material costs means that production cost continued to decrease.

Quite different factors are brought out in the twenty-five year plotting of *Engineering News-Record's* construction cost index, given in Fig. 9. Before studying this, it is well to look at the volume and cost indexes of the last seven years, diagramed in Fig. 7. Here it is apparent that construction cost has been kept down and is now decreasing, during a period when volume of construction grew tremendously; it is to be noted that the volume plottings in Fig. 7 are physical volume rated on a 1913 price base and therefore are unaffected by the depressed purchasing power of the present time.

That it should be possible to show a continuing decrease in construction cost index under these conditions, seems to be unmistakable proof of progressively increased efficiency of engineering and construction.

Fig. 9 shows that prior to the war the cost index had minor oscillations but on the whole tended to maintain a fixed value. Then came a period of violent disturbances, swinging up and down in wave like changes, up to four or five years ago. The oscillations are now tending toward a new stable value. Whatever factors were responsible for the large fluctuations of cost level during and after the war period, these factors are now out of action and we are in a stable period comparable to that of twenty years ago. We may therefore expect a gradual reduction of construction cost in proportion to the progressive improvement of the art, but no abrupt or extensive changes.

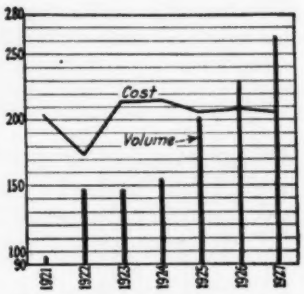


FIG. 7—E. N.-R. INDEXES OF CONSTRUCTION COST AND VOLUME
(Engineering News-Record Statistics)

One element of the situation that has been under discussion during the late months of 1927 is the so-called "profitless prosperity." The reference is to lowering profit margins and competition for business. Competition always exists in a soundly arranged business structure and it is impossible to conceive of business on the whole going along without profit. The steady progress in improving the efficiency of production, however, as reflected in the slow but maintained decrease in material prices, is certain to be accompanied by a reduction of profits for the less efficient producers. So long as the capacity is ample it cannot be considered a serious matter if profits are earned only by the efficient producers.

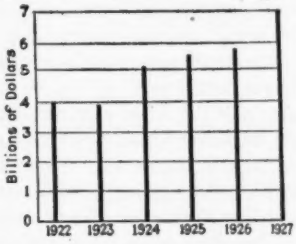


FIG. 8—NEW CAPITAL FLOTATIONS
(For 11 months, 1922-1927. Source: Commercial and Financial Chronicle)

Speculation and inflation have also been discussed, mainly because of a steady marking up of stock market prices during the past two years or more. But since commodity price levels in general have remained constant or gone down, it seems clear that there is no general speculative element in business.

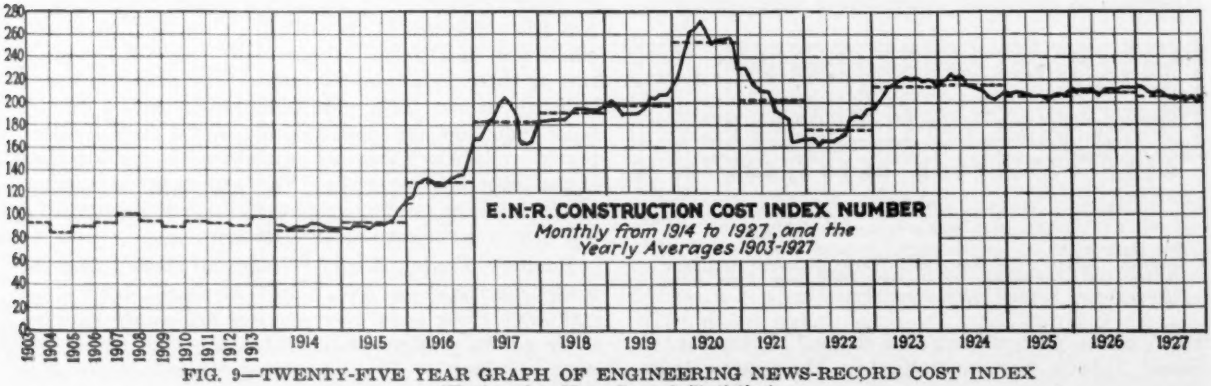


FIG. 9—TWENTY-FIVE YEAR GRAPH OF ENGINEERING NEWS-RECORD COST INDEX
(Engineering News-Record Statistics)

Further, the stock market inflation has not affected the general trend of business, nor has it restricted the sources of credit for commercial and production operations. A comparative plotting of new capital invested in industry during the last six years, Fig. 8, indicates that the supply of capital for industrial purposes is adequate.

A Favorable Prospect—The general factors of the situation of business and construction at the close of the year were tersely stated by Herbert Hoover in the annual report of the Commerce Department: "There is an ample supply of credit at low rates; the somewhat larger stocks of goods which were accumulated during the summer are being reduced; there is no consequential speculation in commodities; the crops have been abundant; wages are at a high level; we are recovering from some partial unemployment, especially in the automobile industry. There is more peace in most sections of the labor world, except bituminous coal; there is more peace in the international world than at any time since the war; the foreign world is recovering its economic strength and buying power, therefore, our foreign trade is steadily increasing. The phenomena usually accredited as premonitory of a slump are therefore absent."

Thus, having just concluded a year of exceptionally high construction activity with at the same time a slight decrease of operating costs, we face a promising year. The demand for further construction appears to be growing at a sufficient rate to call for fully as much activity during 1928. There are no disturbing elements in sight as concerns labor prices or employment. The price level of materials, as well as of labor, should maintain itself fairly uniform, with a slight decrease, if anything. Regardless of a probable further decrease in residential construction, engineering construction (including large building work) promises to show a further rise. Public works construction is on the upswing and private work in the field of heavy construction and building is also likely to surpass its 1927 total.

LARGE INDUSTRIAL BUILDING CONTRACTS LET IN 1927
(Reported in *Engineering News-Record*)

Job and Location	Owner and Contractor	Price
Rayon plant, Happy Valley, Tenn.	American Glanzstaff Co. (Contr.) (Steel) McClintic-Marshall Co., N.Y. City (Foundation) Hughes-Foulkrod Co., Philadelphia, Pa.	$37,500,000
Hydro-electric plant, Saluda River near Columbia, S. C.	Lexington Water Power Co. U. S. Barstow Management Assn., N. Y. City	20,000,000
Factory, Pontiac, Mich.	Yellow Truck & Coach Mfg. Co. (Contr.) J. A. Utley, Detroit	8,000,000
Factory, Los Angeles, Calif.	Firestone Tire & Rubber Co. By separate contracts	7,000,000
Mills, Gary, Ind.	American Sheet & Tin Plate Co. (Contr.) Great Lakes Construction Co., Chicago	6,000,000
Factory, Belvedere, Calif.	B. F. Goodrich Co. (Contr.) Foundation Co., New York City	5,000,000
Electric generating plant, Hopewell, Va.	Atmospheric Nitrogen Co. (Contr.) Stone & Webster, Boston, Mass.	5,000,000
Power plant, Tampa, Fla.	Tampa Electric Co. (Contr.) Stone & Webster, Boston, Mass.	5,000,000
Car shops, New York City	Board of Transportation (Contr.) Eastern Construction Co., N. Y. City	4,170,000
Tower plant, Beaumont, Tex.	Gulf States Utilities Co. By day labor	4,000,000
Rayon plant, Old Hickory, Tenn.	Du Pont Rayon Co. By day labor—Du Pont Engineering Co., Wilmington, Del.	4,000,000

LARGE BRIDGE CONTRACTS LET IN 1927
(Reported in *Engineering News-Record*)

Bridges	Contractor	Price
	Rhode Island	
Bristol-Portsmouth	Mt. Hope Bay Bridge Co. Foundation Co., New York, N. Y. McClintic-Marshall Co., Pittsburgh, Pa.	$3,500,000
	Connecticut	
Yellow Mill Bridge	Bridge Comm. C. W. Blakeslee & Son., New Haven, Conn.	$1,097,870
	New York	
Viaduct and Approaches	New York City P. T. Cox Contg. Co., New York, N. Y.	1,797,552
Fort Lee-Fort Washington	Port Authority Anchorages and approaches—Foley Bros., Inc. Jersey City, N. J.	694,000
	Foundations—S. B. Mason, Inc., New York City	1,160,200
	Cables—John A. Roebling Sons Co., Trenton, N. J.	12,339,977
	Steel towers and floors—McClintic Marshall Co., Pittsburgh, Pa.	10,134,440
Mid-Hudson	Dept. Pub. Works, Albany American Bridge Co., New York City	2,963,259
	New Jersey	
Hackensack River	Delaware, Lackawanna & Western R.R. Approaches—H. F. Curtis, New York City. Steel—American Bridge Co., New York City. Foundations—Foundation Co., New York City. Lehigh Valley R. R. Co., and Pennsylvania R.R. Co.	$3,000,000
Newark Bay	A. McMullen, New York City. Henry Steers, Inc., New York City.	4,000,000
	Pennsylvania	
University Bridge	Dept. Pub. Works. Dravo Contg. Co., Pittsburgh, Pa.	1,288,625
	Virginia	
James River	James River Bridge Corp. Turner Constr. Co., New York City.	5,000,000
	Ohio	
Cincinnati Viaduct	Dept. Highways & Pub. Wks. Folwell Ahlskog Co., Chicago, Ill.	1,851,829
	Michigan	
Detroit International Bridge	American Transit Co. McClintic Marshall Co., Pittsburgh, Pa. Foundation Co., New York City.	2,000,000
Mississippi River at Alton, Ill.	Illinois and Missouri. Alton-St. Louis Bridge Co. Kansas City Bridge Co., Kansas City, Mo.	866,610
	Wisconsin Bridge Co., North Milwaukee, Wis.	436,618
	Rause Constr. Co., Cape Girardeau.	381,382

LARGE ROAD CONTRACTS LET IN 1927
(Reported in *Engineering News-Record*)

New York	
State Comr. Highways.	
A. C. Baily, Phillipsburg, Pa.	$4,990,215
H. T. Gunston, Eden, N. Y., and others.	4,060,790
Stapell, Mumm & Beals Corp., Gardenville, N. Y., and others.	3,574,090
P. Lucian & Son, White Plains, N. Y., and others.	1,901,027
C. D. Murray, Syracuse, N. Y., and others.	1,860,558
New Jersey	
State Highway Comn.	
Montrose Constr. Co., New York, N. Y.	3,244,[illegible]51
West Virginia	
State Road Comm.	
F. C. Sammons, Huntington, W. Va.	2,794,729
C. V. Rector, Spencer, W. Va., and others.	2,180,416
North Carolina	
State Hy. Comm.	
L. G. Smith & Co., Ashville, N. C., and others.	2,252,181
J. F. Mulligan Constr. Co., North Wilkesboro, N. C., and others.	2,187,841
Florida	
State Road Dept.	
Manley Constr. Co., Leesburg, Fla., and others.	2,073,226
Johnson, Drake & Piper, Minneapolis Minn., and others.	2,070,386
Illinois	
State Dept. of Pub. Works & Bldgs.	
H. Zalper & Sons, Mendota, Ill., and others.	2,138,282
H. H. Hall Constr. Co., East St. Louis, Ill.	1,978,250
Iowa	
State Highway Commission.	
McCarthy Constr. Co., Davenport, Ia., and others.	3,414,455
Rock Island Cement Co., Rock Island, Ill., and others.	2,268,910
National Constr. Co., Omaha, Neb., and others.	2,108,472

LARGE SUBWAY CONTRACTS LET IN 1927

Location	Contractor	Price
New York, N. Y. Route 78, Sect. 6-C West 173rd to West 177th Sts.	Slattery Engr. & Constr. Co. 10 East 42nd St.	$1,323,362
New York and Brooklyn, N. Y. Route 101, Sect. 1. Church and Fulton Sts., New York City and Cranberry, Furman and High Sts., Brooklyn	Mason & Hangar Co. 52 Vanderbilt Ave.	$22,282,309
New York, N. Y. Route 104, Sect. 1, 2 and 3 West 53rd St.	Patrick McGovern Co. 50 East 42nd St. Sect. 1 & 2 Sect. 3	9,700,195 10,481,550
Brooklyn, N. Y. Route 109, Sect. 1 Jay St., Nassau to Willoughby Sts.	Carleton Co., Inc. 151 West 42nd St.	3,758,993
New York, N. Y. Route 45, Sect. 1 and 2 Nassau St. and Park Row	Marcus Contg. Co. Sect. 1 305 Broadway Moranti & Raymond Sect. 2 42 Broadway	4,722,885 5,735,149
Long Island City, N. Y. Route 107, Sect. 13 Jackson Ave., Arch and Queens Sts.	Atwell, Gustin & Morris Co. 1 Park Row	5,198,284
Long Island City, N. Y. Route 107, Sect. 12. Manhattan Ave., Newton Creek Vernon and Jackson Aves.	Mid Eastern Contg. Corp. 236 West 116th St.	6,946,895
Philadelphia, Pa. Contract 109 South Broad St.	Hegman & Goodman Co., Inc. 880 8th Ave.	7,629,880

News of the Week

Current Events in the Civil Engineering and Contracting Fields

Work's Advisers Urge Building of Boulder Canyon Dam

Four advisers, from whom Secretary Work requested reports on the project, have reported favorably on the construction of the Boulder Canyon dam. They are James R. Garfield, former Secretary of the Interior, Governor Emerson of Wyoming, former Governor Scrugham of Nevada and Prof. William F. Durand of Stanford University. The Garfield report urges immediate construction, mainly because of the flood menace to the Imperial Valley; the Scrugham report also advises immediate action, though the power aspects of the dam construction are stressed; Governor Emerson points to the urgent need for flood protection but insists on the ratification of the Colorado Compact prior to any development; and Professor Durand stresses the general engineering features of Colorado River development including the All-American canal. A fifth report requested, that from Senator Waterman of Colorado, has not yet been filed.

It is expected the reports will be utilized when the House Irrigation Committee resumes hearings on the Boulder Canyon dam bill.

Superstructure Contract for Arlington Bridge Let

Contract for the construction of the superstructure of the Arlington memorial bridge across the Potomac River at Washington, D. C., has been let to the Hunkin-Conkey Construction Company of Cleveland for $1,576,686. The contract price includes construction of eight reinforced-concrete spans with white granite facing and the approaches but does not include the bascule draw span.

Port Authority Sells Kill van Kull Bridge Bonds

The Port of New York Authority last week sold an issue of $12,000,000 of bonds for the Kill van Kull bridge between Bayonne, N. J., and Port Richmond, S. I. Bonds were sold at the low interest cost of 4.01 per cent. Nearly all the real estate on the Bayonne side has already been acquired and several test pits have been completed to determine the nature of the subsoil on the Bayonne approach. Similar work is under way at Port Richmond. Topographical surveys are being made.

Ontario Hydro Plans Extension

Extensive plans for the industrial needs of the Algoma and Sudbury districts in Canada have been announced by C. Alfred Maguire, chairman of the Ontario Hydro Electric Power Commission. The program includes the generation of from 125,000 to 140,000 hp. on the Mississauga River, 30,000 hp. on the Montreal River, and 12,000 hp. on the St. Mary River.

Chicago's Water Badly Tainted by Phenol in Wastes

Winds Carry Coke-Oven Wastes from Indiana Towns—Engineer Dismissed

EXCEPTIONALLY bad taste of the water supply in a large part of Chicago during the last week of 1927 was due to sewage and industrial wastes from the group of Indiana towns at the south end of the lake being blown much farther north than usual by strong winds. This pollution invaded five of the six intakes. Increased dosing with chlorine made the water safe though unpleasant. The bad taste was due largely to phenol in the wastes from coke-oven plants; tests of the water show 60 parts of phenol per billion.

There is normally no phenol content in the water and the normal chlorine dose to counteract sewage pollution is about 2 lb. p.m.g. After the storm the chlorine was increased to a maximum of 13.6 lb. The combination of chlorine and phenol made the smell and taste of water peculiarly offensive, and led to much public complaint. This occurrence was repeated to a less serious extent on Jan. 7, when it was necessary to make the chlorine dose 10 lb., reduced to 5 lb. on Jan. 8 after the wind had changed. As a result of these experiences, further attempts will be made to check the pollution of the lake by the towns and industrial plants south of Chicago.

Sanitary Engineer Dismissed

Following the flood of consumers' complaints of bad taste in the water the commissioner of public works summarily suspended Arthur E. Gorman, chief sanitary engineer. The cause for this removal was first laid to a recommendation by Dr. Kegel, the new health officer of Chicago, and was connected with the bad tastes in the water. Later reports indicate that the suspension, leading to removal, had been determined previously, as an administration measure. Mr. Gorman having refused to resign, charges will have to be made to effect his removal, but his successor has already been named, as announced under Personals, p. 94.

Power Development at Lac Seul Agreed Upon

Decision to proceed with construction of a storage dam for water power development at Lac Seul, on the English River, in Northern Canada, was reached at a conference recently of Dominion, Ontario and Manitoba officials, in Toronto. Ontario will retain complete ownership of the dam, which will be on the Ontario side of the Manitoba-Ontario boundary, but operating control will be turned over to a control board similar to that operating the Lake of the Woods Norman dam.

The dam is to be built on plans of engineers of the Ontario Hydro Electric Power Commission, who surveyed the site last summer. A total of 250,000 hp. is possible at Lac Seul, near Sioux Lookout, and this power will be available also for the Red Lake mining district, for the Northwestern pulp and paper industry, for the proposed Red Lake railway branch, and for additions to Winnipeg's domestic and industrial supply.

Smith Again Urges Establishing State Power Authority

In his eighth annual message to the New York State Legislature, Governor Smith renewed his request for the establishment of a New York State Power Authority. In his latest request he suggests that such authority if created prepare a comprehensive plan dealing with the production and distribution of hydro-electric power before any development is undertaken. He would pattern such a power authority after the port of New York authority, whereby power would be developed, the cost being met by bond issues to be refunded and interest paid by earnings on such improvements.

Elevated Boulevard for Chicago

An elevated street ten miles long, extending diagonally to the northwest corner of the Chicago city limits is proposed on Avondale Ave., as a new automobile route serving a number of heavy-traffic main highways which converge at its outer end. It will be 210 ft. wide, having a 160-ft. roadway, with central ramps connecting with 23 principal intersecting streets. For most of its length it will be parallel with and adjacent to the elevated line of the Chicago & Northwestern Ry. and will have on the other side a 50-ft. low-level roadway, at street grade. This project has been approved by the Chicago Plan Commission and the Board of Local Improvements. Its cost is estimated at $59,580,000.

Code of Practice Adopted by Illinois Engineers at Their Annual Convention

Active discussion which was a feature at the annual meeting of the Illinois Society of Engineers, held at Urbana, Ill., Jan. 4-6, was due in part to restricting the number of papers and avoiding an overcrowded program. Specially active were the discussions on sewage treatment, the legal aspects of engineering work done by special assessment, recent state legislation of interest to engineers, and the state licensing of surveyors. Another point of interest was a report by a committee of past presidents, suggesting methods for increasing the membership and extending the activities of the society. The code of practice prepared by the American Society of Civil Engineers was adopted on recommendation of the committee on Ethics and Fees, which pointed ont that this code is good in itself and that a uniform code is desirable.

Tunnel ventilation was an unusual subject which proved interesting. The Holland Tunnel ventilation system and the experiments made at the University of Illinois in connection with it were described by Professor A. C. Willard, while Professor A. C. Callen dealt with coal-mine ventilation studies. In the discussion, E. E. R. Tratman, of *Engineering News-Record*, referred to the ventilation problem of the Moffat Tunnel, six miles long, which is to be operated by steam locomotives. Papers on electric power in coal mining, the mineral industries of southern Illinois and aerial surveying were also somewhat outside the usual field of subjects. Controversy over the state law for licensing surveyors developed when a suggestion was made that the law should be statewide instead of applying only to Cook County, as at present. It was claimed that this fact of their being licensed gives the Cook County surveyors an advantage over others on outside work. On the other hand, the outside or downstate surveyors have persistently opposed any state-wide law.

Sewage Treatment

Sewage treatment methods and plants in Europe were reviewed in two papers, while a review of such plants in Illinois has shown that many of them are inadequate to meet the requirements of increasing population. A paper by F. C. Roe, described the new plant at Princeton, which is the first in Illinois using the Simplex process, producing activated sludge by surface contact with the air instead of delivering air below the surface. Experiments with this British process have been made by the Chicago Sanitary District, and several plants have been built in this country. The cost is given as $60,000 to $100,000 per m.g.d., with 20 hp. for aeration per million gallons, both figures said to be somewhat lower than for the air-diffusion process. Two papers on water supply dealt with a pumping station at Galesburg and the new water-works plant being built at Glencoe as the contract for a supply from an adjacent town expired in September, 1927. This system, to be ready next April, includes a 3,000 ft. intake line of 24-in. cast iron pipe, extending to water 23 ft. deep in Lake Michigan, motor-driven high and low-lift pumps with gasoline driven emergency units, a coagulating basin, 500,000 gal. clear well and four filters with a capacity of 3 m.g.d. The Illinois River floods of 1927, the maintenance of drainage ditches, and different aspects of highway development rounded out a diversified program.

Officers elected for 1928 include: President, J. A. Moore, assistant engineer in the Board of Local Improvements, Chicago; vice-president, Professor M. L. Enger, University of Illinois. The secretary is H. E. Babbitt, Urbana, Ill. The 1929 meeting is to be held in Chicago.

Anti-Stream Pollution Work in the Ohio Valley

Beginning with the health authorities of Pennsylvania, Ohio and West Virginia, those of other states have joined in co-operative work to prevent stream pollution in the Ohio Valley until nine are banded together with two or more in prospect. The six stated added to the original agreement are Kentucky, New York, Maryland, Illinois, Indiana and Tennessee. According to *Ohio Health News* for Dec. 15, "Virginia and North Carolina have asked to be admitted." The *News* states further that "Only three states touching the Ohio drainage area will be outside of the fold" when Virginia and North Carolina come in. These three are Georgia, Alabama and Mississippi, "of which only Alabama has any considerable area in the Ohio basin."

In December, 1927, the chief sanitary engineers of the nine states, with corresponding officers for North Carolina and Virginia as guests, met in Louisville, Ky., as an engineering board for the Ohio valley serving "under direction of the health commissioners" of the nine states. The engineering board has as chairman W. L. Stevenson, chief engineer of the Pennsylvania Department of Health, and as secretary, F. H. Waring, chief engineer of the Ohio State Department of Health, Columbus, Ohio.

Overhead Rail Crossing for Baltimore Approved

The Board of Awards, Baltimore, has approved plans for a viaduct to carry the tracks of the Baltimore & Ohio Railroad and the Western Maryland Railway over Russell Street and Gwynn's Falls, in Southwest Baltimore. It will be 305 ft. long and the cost is estimated by Charles F. Goob, chief engineer of the city, at $250,000. Bernard L. Crozier, formerly chief engineer of the city, has been engaged to design the viaduct and supervise its construction.

Water Supply for Niles And Youngstown Planned; Would Cost Nine Million

The constitutionality of the act under which the Mahoning Valley Sanitary District, comprising the cities of Youngstown and Niles, Ohio, was formed, was upheld on Dec. 29 and the general plan for a joint water supply for the two cities formulated by the engineers of the district and approved by the district commission has been sanctioned by the courts of common pleas of the two counties in which the district is located.

The estimated cost of the project is $9,150,000, divided as follows:

Mineral Ridge dam and reservoir	$3,782,000
Purification and pumping works	2,310,000
Pipe lines and covered distributing reservoir for Youngstown	2,662,000
Pipe lines and standpipe for Niles	396,000

An impounding reservoir with a capacity of 10,000 m.g. will be formed on Meander Creek, a tributary of the Mahoning River, the dam being 7.8 miles west from the center of Youngstown, and about 2 miles south of the center of Niles. The dam will have a total length of 3,550 ft. and will consist of a concrete spillway about 50 ft. in height, with crest at El. 905, flanked on either end by an earth embankment with concrete core-wall. With the water level 7 ft. above the crest the capacity of the spillway will be 18,000 sec.-ft. or 208 sec.-ft. per square mile of drainage area. The safe yield of the 87 square miles of drainage area is estimated at 0.43 m.g.d. per square mile of drainage area or a total of 37.4 m.g.d.

Water coagulation, filtration and softening works, the latter to reduce hardness from an average of 135 to 100 p.p.m. or less, is planned to have a rated capacity of 42 m.g.d., sufficient to yield an average of 32 m.g.d. in combination with the storage provided. Enlargement to 80 m.g.d. is feasible.

Pumping equipment will be all steam-turbine-driven centrifugal with an initial installation of a 25-m.g.d. low-lift pump for occasional use and three high-lift pumps, two of 25 and one 17.5 m.g.d. capacities, all for the joint supply of Youngstown and Niles. The pumps, located at the dam and filtration plant, would force water to Youngstown through duplicate 36-in. mains about 28,000 ft. long, delivering to a new distributing reservoir in the western part of the city from which two 36-in. mains about 13,000 ft. long will connect with the existing distribution system.

On completion of the joint works, the present filtration plants at Youngstown and Niles, which draw badly water from the Mahoning River, would be discontinued. The Youngstown pumping station would be retained for booster purposes to supply the high service. No re-pumping at Niles would be required.

The chief engineer for the Mahoning Sanitary District is W. H. Dittoe. G. Gale Dixon is deputy chief engineer in charge of office studies and design, and C. B. Cornell has been field engineer.

Water-Works Manual Discussed at N. Y. Section Meeting

At the luncheon meeting of the New York Section of the American Water Works Association on Dec. 28, it was decided to hold a two-day meeting in New York City hereafter, instead of a luncheon followed by a business and professional meeting. The meeting was devoted to a discussion of Chapters 1 to 12 and Chapter 16 of the Manual issued by the association. The discussion on the first five chapters, "Collection and Quality of Water," was opened by Allen Hazen, New York City. The next seven chapters, "Treatment of Water," were taken up by Dr. Frank E. Hale, of the Department of Water Supply, New York City; discussion of Chapter 15, "Pumping," was opened by F. G. Cunningham, of Fuller & McClintock, New York City.

Public water supplies now having been made safe, Mr. Hazen expressed the hope that in future it would be possible to make sure that they can be used with pleasure. He hoped that the next edition of the Manual would go into ways and means of providing cool water.

C. A. Holmquist, Albany, N. Y., suggested that in the next revision attention be given to the co-operative agreements between states for control of pollution. He mentioned the fact that by such action in conjunction with industrial companies trouble from phenol wastes has been put under close control by 21 plants in one group of states, while it is expected that by the middle of 1928 the one remaining plant will be under control.

Prof. E. B. Phelps, Columbia University, said that in view of recent studies of the toxic effect of copper service pipes and the increasing use of such material, the copper limit standard might safely be raised. A detailed critical examination of Chapters 6 to 12, "Water Treatment," was presented by Dr. Hale, who remarked that this section needs an entire volume instead of 132 pages. Frank W. Green, Little Falls, N. J., stressed the desirability of determining, before changes in the Manual are made, whether the book is designed for operators of small water-works or for technically trained men. Important subjects have been slurred over and too much space given to some of current interest. For instance, iodine treatment for goiter control, used by only two or three cities, has eighteen pages or almost as much as is given to filtration.

Chapter 15, "Pumping," said Mr. Cunningham, lacks balance in allocation of space, giving about 50 per cent to boilers, 40 per cent to pumping in general and 10 per cent to well pumps. He thought that well pumps should be treated in a separate chapter and given more space in view of the large number of water supplies drawn from under ground. The section on Boilers, Mr. Cunningham stated, contains good material and is well written, but hardly belongs in the Manual as the information presented can readily be found elsewhere. The Manual contains nothing on the relative values of different kinds of pumps. A new chapter, dealing with general principles, might well be provided. Notwithstanding the fact that the average population of places having water-works is 10,000 or less, requiring average supplies of 1 m.g.d., all of the text on pumping seems to deal with larger plants. In a written discussion sent by Leon Small, mechanical engineer, Baltimore Water Department, the opinion was expressed that the Manual does not give enough space (only 4 pages against 18 to boilers) to motor-driven pumps which in a few years the writer said would probably be in the ascendency.

American Concrete Institute Announces Its Program for Twenty-fourth Convention

Of widespread interest are the papers listed in the preliminary program for the annual convention of the American Concrete Institute to be held in Philadelphia Feb. 28, 29 and March 1. Workability of concrete will be discussed in a number of papers. W. E. Hart, manager of the Structural and Technical Bureau of the Portland Cement Association, will present an illustrated paper on "Reinforced Concrete Walls for Buildings." Other papers include one on "Crazing" by P. H. Bates, of the U. S. Bureau of Standards, together with a joint paper on this same subject by Alfred H. White, professor of chemical engineering at the University of Michigan, and two of Mr. White's associates.

An exhaustive report has been prepared on more precise concrete control for presentation to the Institute convention by Herbert J. Gilkey, associate professor of civil engineering at the University of Colorado. "Testing Concrete in the Field" will be discussed by C. A. Wiepking, now of the Department of Public Works of Milwaukee, and formerly of the University of Wisconsin. "Semi-Circular Hooks" is the subject of a paper by T. D. Mylrea, of the Carnegie Institute of Technology, and "Flow of Concrete Under Continued Compressive Stress" one to be read by Raymond E. Davis, professor of civil engineering, University of California.

Of particular interest will be the presentation of a concrete primer which covers the entire concrete field. Other subjects to be discussed in regular papers are skew arches, better concrete, floor finish, plant design and drying out the shrinkage after curing. An exhaustive paper has been prepared by Arthur R. Lord, of Lord & Holinger, Chicago, on "Design and Cost Data for Proposed 1928 A.C.I. Standard Building Code."

The nominating committee has reported the following nominations for offices to become vacant at the next convention: President (term one year), Edward D. Boyer, New York; vice-president (term two years), Duff A. Abrams, New York; treasurer (term one year), Harvey Whipple, Detroit, Mich.; directors, first district (term two years), A. C. Tozzer, Boston; second district (term two years), John G. Ahlers, New York; and sixth district (term two years), R. J. Wig, Los Angeles.

Cost Analysis Interests Illinois Contractors

Detailed analysis of construction costs, to show where the money goes and what is the actual remainder or net profit left for the contractor, was a subject listened to with deep interest by a large attendance at the annual meeting of the Illinois Association of Highway and Municipal Contractors, held at Chicago on Dec. 13 to 15. The method of such analysis was presented by A. H. Hunter, engineer for the association.

In reviewing present and prospective road work, Frank T. Sheets, chief engineer of the Illinois Division of Highways, predicted five years of exceptional activity, especially if the Supreme Court sustains the new gasoline tax. For 1928, he estimated an expenditure of $57,000,000 for concrete paving, grading and bridges. He blamed the existence of irresponsible contractors partly upon equipment and material firms in giving long credits to such men, while responsible contractors pay their bills regularly. The Illinois gasoline tax law was advocated strongly by D. O. Thomas, county superintendent of highways at Belleville, Ill., as a reasonable method of raising road funds for state and county work. But he also advocated better accounting and auditing of official bodies to insure that these funds are expended only for their intended purpose. The activities of the Associated General Contractors of America were outlined by Ward Christie, engineer for the association. In discussion of these activities, Alan J. Parrish, Paris, Ill., referred to the problem of the outside contractor who invades the field of the local contractor but has none of the local obligations of the latter and does little to benefit local labor or material men. He suggested that this problem is matter for educational treatment, which can be given only by a national association.

Relations between contractors and engineers were reviewed by E. Roy Wells, of the Wells Engineering Company, Geneva, Ill., and C. M. Powell, of the Sternberg-Powell Contracting Company, Chicago. They referred to the evils of work under an engineer inexperienced in construction, or by a contractor whose only aim is to do work that will pass. But both agreed that even with an experienced engineer and a conscientious contractor, it is necessary to have co-operation between them in order to insure the best work, the best return for public money invested and the best profit for the contractor. Alan J. Parrish, Paris, Ill., was re-elected president. The new secretary is H. F. Boron, Chicago.

Concrete Toll Highway for Northwest Canada Planned

Construction of a 24-foot wide solid concrete toll highway between Calgary and Banff, Alberta, will be undertaken early this year if the Alberta Legislature will grant the necessary charter, according to an announcement made by Daniel F. Whitney, president of the Alberta Hotel Association, and director of the Alberta Motor Association. The work will be undertaken by a company named Trackways Company, Limited, the incorporation papers of which are already under preparation. The length of the road will be approximately 70 miles and will probably traverse the area of the south side of the Bow River for a large part of the distance.

Sault Ste. Marie Votes for Private Power

The citizens of Sault Ste. Marie on Jan. 2 voted by a large majority to accept the proposal of the Great Lakes Power Company, of Chicago, to supply power to be developed at St. Mary's rapids. It is estimated that there remain 12,000 hp. available for development at this point at a cost of $2,005,065, and that it can be supplied to consumers at a cost of $17.16. The Ontario Hydro Electric Power Commission opposed the project and as an alternative proposal offered to supply 9,215 hp. from developments on the Montreal and Mississauga Rivers at a cost for development of $1,433,425, at $15.75 per hp.

Railways to Perfect Motor Transport Organization

Representatives of railroads throughout the United States and Canada will meet in Chicago Jan. 25 and 26 to effect a permanent organization of the recently-created Motor Transport Division of the American Railway Association. The creation of this division resulted from the fact that a large number of roads now supplement rail service with motor buses.

George M. Campbell of New York, assistant to the secretary of the American Railway Association, is the secretary of the new division.

Purdue to Hold Road School

Purdue University, under the direction of the school of civil engineering and the engineering extension department, co-operating with the Indiana State Highway Commission, the Indiana State Highway Superintendents' Association, the City Street Commissioners' Association of the state of Indiana and the Highway Materials and Equipment Association, will hold its fourteenth annual road school Jan. 16 to 20. Aside from the general subjects devoted to highway design, construction and maintenance, there will be special sessions for county surveyors and engineers, state highway men, county highway superintendents and city officials.

Random Lines

More of the Same

(233) *Die Engineers*—A Baltimore firm that designs and "builds" dies.

(234) *Screen Engineers*—New Orleans planners and designers of "screens that not only will do justice to the architectural requirements of your home, but which are also well built," etc., etc.

(235) *Paper Engineers*—Someone seeking employment through the medium of the Yale Alumni Weekly.

(236) *Shackle Engineer*—A "specialist" in the business of making automobile riding easier who is available for consultation in New Britain, Conn., on installation of ball-bearing spring shackles.

(237) *Saxophonist and Clarionet Engineer*—Ace Buckner, from somewhere in the great Southwest, who supplies part of the music at "Peacock Terrace" in an unnamed city.

(238) *Type Engineer*—The title of a recently created position on the Washington *Post*.

(239) *Washman Engineer*—Just a Boston laundryman.

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Most Recent List—Engineers

Acoustical
Adhesive
Advertising
Aerial
Aesthetic
Air
Amusement
Analyzation
Anatomical
Appearance
Aquatic
Arctic
Arrangement
Automobile
Automotive Painting

Baking or Bakery
Ballistic
Baseball Park
Beater
Beauty
Belting
Biology
Blasting
Body
Box
Brewery
Business
Byproduct

Cafeteria
Calfskin
Carbonating
Carbon
Casement Window
Cash Register
Casualty
Catalog
Caterpillar
Chain Store
Check Writing
Chiropractic
Cinematograph
Civilization
Clamshell
Cleaning
Clothes
Clothing
Color
Commencement
Communication
Condemnation
Container
Correspondence
Cost Cutting
Crating
Crime
Criminal
Cryogenic
Crystallizing
Culinary

Dansant
Decorative
Demolition
Dental
Dehorning
Development
Dehydration
Diet Kitchen
Diplomatic
Diplomatic Sub
Display
Domestic
Draftsman
Dress
Dry Cleaning
Dust
Dwelling

Economic
Economist & Estate
Efficiency
Electric Sign
Experimental
Export
Exterminating

Fabric
Facial
Feed Plan
Floor Covering
Food
Forgery Prevention
Fiction
Filmgineer
Financial
Fish Screen
Floor
French Hat
Fumigating
Furnishing
Furniture

Garage
Good Taste

Historical
Home
Horse
Horticultural
Hospitalization
Hot Dog
Hotel
Household
Human
Hybrow
Hydrostatic
Hymn Book

Ice
Ida
Imaginative
Income
Industrial
Insurance
Investment

Jailbreak
Janitor Engineering
Jazz

Kitchen

Laboratory Furniture
Lace
Laminated Wood
Lawn Mower
Leasing
Life Saving
Light Carriage
Lingerie
Liquidating

Magnetic Housecleaning
Man
Management
Market Development
Mattress
Mechanical Air
Membership
Merchant
Milk
Moonshine
Moral
Mosquito
Motion Picture
Mowing

News
Nutrition

Odor
Office Equipment
Optician
Organ
Organization
Osteopathic

Package
Packing
Pageant
Paint
Paint Maintenance
Patent
Pediatric
Pharmaceutical
Photographic
Platter
Playground
Pneumatic
Police Signaling
Political
Practical Heating
Preservation
Pressing
Printing
Products
Progress Engineers & Zodiac Readers
Projection
Psychic
Psychological
Public Relations
Publicity
Purchase

Real Estate Sales
Record Protection
Recreation
Research Engineers on Technical Publications
Results
Revolutionary
Rolling Pin

Sales
Scenic
Scientific
Seasoning
Seating
Second Story
Shingle
Shoe Surface
Short Story
Smuggling
Sign
Sleep
Social
Society
Socio-Religious
Soft Drink
Soft Floor
Space
Space Saving
Spiritual Engineering
Standardization
Surface Protection

Taxation
Time
Tire
Trade Catalog
Tramrail
Travel
Trunk
Turf
Typographical

Vacuum
Vault
Vision
Vital
Vocational

Wet
Wedding
Window Shade
Wrapping
Wrecking

Personal Notes

EDWARD G. GUTHRIE, former city engineer of Buffalo, who has been in public service for almost 50 years, retired Jan. 1 from his position with the grade crossing and terminal commission. Mr. Guthrie is a graduate of Yale College and Rensselaer Polytechnic Institute and began his professional career with the Buffalo and Southwestern Railroad. He remained there until 1874 when he was appointed an assistant to the city engineer of Buffalo in charge of sewers, which position he held five years. After several years of general engineering and some manufacturing experience, he returned in 1886 to Buffalo as deputy engineer.

CHARLES E. JOHNSON, vice-president and general manager, Kansas City Southern Railway, has been elected president of that road. He succeeds J. A. Edson, who retired Jan. 1. Mr. Johnson entered the employ of the Kansas City Southern in 1906 as a locating engineer, and rose to the position of division engineer shortly thereafter. He was made chief engineer and general manager in 1914, and was elected a vice-president in 1924. He entered the railroad business with the engineering department of the Chicago, Paducah & Memphis Railway in 1897, later being employed by the St. Louis-Southern, Chicago & Eastern Illinois, the St. Louis & San Francisco and the Missouri Pacific system.

E. N. TODD, for four years state highway engineer of Kentucky, has resigned, his resignation to become effective Jan. 31. Mr. Todd has been with the Kentucky Highway Department since July 1, 1924, first as engineer of construction. Prior to that date he was with the Oklahoma Highway Department. In 1906 to 1920 he was in the federal civil service with the Construction Division of the Army, seven and one-half years of the time being rated civil engineer and superintendent of construction. He has had highway experience in six states, the District of Columbia and the Philippine Islands.

R. M. SMITH, chief engineer of the Highways Department of Ontario, Can., has been appointed deputy minister of highways. He is a graduate of Queen's University, Kingston. He is succeeded as chief engineer of the department by A. A. SMITH, who has for some time occupied the position of assistant engineer.

COVINGTON K. ALLEN, a civil engineer, has been appointed an assistant to Frank W. Jacoby, head of the Bureau of Street Cleaning, Baltimore. The appointment was made by Chief Engineer Charles F. Goob.

H. H. GERSTEIN, assistant sanitary engineer in the division of water safety control, Department of Public Works, Chicago, has been appointed chief sanitary engineer to succeed Arthur E. Gorman.

Engineering Societies

Calendar

Annual Meetings

AMERICAN SOCIETY OF CIVIL ENGINEERS, New York City; Annual Meeting, New York City, Jan. 18-20, 1928.

ASSOCIATED GENERAL CONTRACTORS, Washington, D. C.; Annual Convention, West Baden, Ind., Jan. 23-27, 1928.

NATIONAL ASSOCIATION OF BUILDERS' EXCHANGES, Washington, D. C.; Annual meeting, Miami, Fla., Feb. 6-9, 1928.

ENGINEERING INSTITUTE OF CANADA, Montreal; Annual Meeting, Monday, Feb. 14-16, 1928.

AMERICAN CONCRETE INSTITUTE, Detroit, Mich.; Annual Convention, Philadelphia, Feb. 28, 29 and March 1, 1928.

AMERICAN RAILWAY ENGINEERING ASSOCIATION, Chicago, Ill.; Annual Convention, Chicago, March 6-8.

THE SAN FRANCISCO SECTION of the American Society of Civil Engineers held the annual meeting on Dec. 20. Officers elected for the ensuing year are: President, W. H. Kirkbride, and vice-president, H. D. Dewell. Five-minute talks were made by Harmer E. Davis, student member, University of California, and R. S. Tuttle, student member, Stanford University. The topic of the evening was the Mokelumne water supply project; a general outline was given by Arthur P. Davis, chief engineer, and technical details of the Pardee dam, the 90-mile aqueduct, and other features of the project were described by Frank W. Hanna, hydraulic engineer.

THE KENTUCKY-TENNESSEE SECTION of the American Water Works Association will hold its third annual meeting at Louisville Jan. 19-21.

THE THIRD MICHIGAN ENGINEERING CONFERENCE will be held on Jan. 27-28 at the Hotel Statler, Detroit. Of particular interest to civil engineers on the program are papers on welding, city planning and waterfront development and on the Mississippi River problem. The last named paper will be presented by Arthur E. Morgan, president of Antioch College.

THE CANADIAN GOOD ROADS ASSOCIATION will meet at Quebec, Jan. 24 and 25. Among the questions to be discussed are nationalization of highway signs, uniform speed regulations for the Dominion, construction and maintenance costs, how to eliminate frost damage and the problem of keeping roads open.

THE SPOKANE SECTION OF THE AMERICAN SOCIETY OF CIVIL ENGINEERS has elected H. C. Bender, president. A. I. Buchecker, first vice-president, and C. D. Fosbeck, second vice-president. Walter L. Morgan was re-elected secretary-treasurer.

Obituary

P. J. PARKER of the contracting firm of Parker & Banfield, Portland, Oregon, was killed in an airplane accident near Montpelier, Ohio, recently. His partner, C. H. BANFIELD, was seriously injured at the same time. The firm had been in business in Portland for many years, being among the foremost building contracting firms in that city. The firm also operated the Portland Wire & Iron Works.

GEORGE W. SNYDER, who had been in the maintenance-of-way department of the Pennsylvania Railroad Company for 25 years, died in Philadelphia Jan. 1 at the age of 64 years. At the time of his death he was general storekeeper of the company. Mr. Snyder was born in Pottsville, Pa., was graduated from Lehigh University and entered the service of the Pennsylvania in 1884 as a rodman. In 1907 he became principal assistant engineer of the Western Pennsylvania Division and in 1917 was appointed assistant engineer, maintenance-of-way.

JAMES C. PIERSON, former city engineer of Sacramento, Cal., and a pioneer railroad construction engineer, died recently at his home in Oakland, Cal. Mr. Pierson had spent a large part of his professional life in the West, having superintended construction of the Central Pacific from Sacramento to Oakland, the Southern Pacific from Davis to Red Bluff, and the Western Pacific from Stockton to Marysville. He was city engineer of Sacramento and county surveyor in the period between 1878 and 1889, and was the engineer in charge of early reclamation work in that vicinity.

W. H. GOWAN, assistant U. S. engineer and a resident of Carruthersville, Mo., was drowned at Jackson Bayou, on the Mississippi, Dec. 24. He was 62 years old. He was inspecting some levee work and stepped too near the edge of the bank, the levee caving in under his weight. He had been in the service of the government for 34 years, and at the time of his death was attached to the White River forces.

FRANK J. ROBERTS, one of the best known construction superintendents in Western Ontario and New York State, died in St. Catherines, Ont., on Jan. 5 in his sixty-fourth year. Some of his works include the first power plant at Niagara Falls, Ont., two bridges over the Niagara River and contracts in Trinidad.

EDWARD H. MCGRATH, aged 42, the active head of D. W. McGrath & Son Co., general contractors, Columbus, Ohio, died suddenly Dec. 26. He was president of the Columbus Chapter of the Associated General Contractors of America and was instrumental in its organization about a year ago. He had been associated with his father for more than 20 years and was well known in contracting and engineering circles.

Construction Equipment and Materials

A Section Devoted to What the Manufacturer Is Doing for the Engineer and Contractor

Movement Started to Increase Use of Cotton Bags for Cement

A movement was recently started by the formation of the Cotton Products Extension Committee of South Carolina to increase the use of cotton, and one of the first acts after organization was an appeal sent to the state highway commission stating that "The best interests of our state demand that cement used in highway work be sacked in cotton. If South Carolina will not support her own industries and will not further the use of cotton textile bags, cotton interests will have little hope of inducing other state highway commissions, municipal authorities and others to co-operate in their campaigns for the extension of cotton uses." It was pointed out in the letters, that the highway commissions of Alabama, Florida, Georgia, North Carolina and Virginia already have promised that they will hereafter specify that all cement shipped be packed in cotton bags.

The Cotton Products Extension Committee is said to be similar to committees to be formed in other states in the cotton belt, all of which will work in the fullest co-operation with the Cotton Textile Institute, the United States Government, the American Cotton Growers Exchange, the Textile Bag Manufacturers' Association, and other agencies interested in the movement to increase the use of cotton products.

New Developments

New Features on Small Trench Machine

A new trenching machine to be known as its "Pioneer" model has recently been developed by the Cleveland Trencher Company, Cleveland, Ohio. The new trench machine will cut to a depth of 10 ft. and to a width of 30 in. It embodies a new feature for this size of trench machine in its adjustable soil conveyor. In addition the machine has been designed with extremely compact dimensions.

The soil conveyor or "Pivot-Conveyor," as it is called, is mounted on a pivot arrangement around which it swings on a semi-circular track in an arc of 180 degrees. Its discharge end is therefore adjustable both in height and distance from the machine.

The compact dimensions of the machine permit efficient work in very close quarters, digging within 14 in. of an obstruction being possible. The extreme width of the trencher is less than that of an ordinary sidewalk. The dimensions are: length including boom, 30 ft.; extreme height, 8½ ft.; and width 4 ft. 10 in. Its weight of approximately 13,000 lb. has a low center of gravity and is carried on full crawler tracks. The machine is powered by a Hercules Model L gasoline motor, which develops

38 hp. at 900 r.p.m. Truck-type transmission is used together with bronze and steel worms, and a standard roller chain. Roller and ball bearings, reduction units running in oil, and Alemite lubrication are other features.

New Machine for Placing Power and Telephone Line Poles

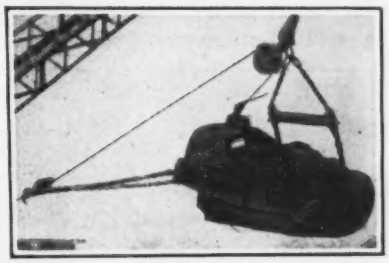
A combination earth boring machine and pole setter, using a Fordson tractor as a power unit, is a new product of the Highway Trailer Company, Edgerton, Wisconsin. It is available either with crawler tracks of the company's own manufacture, or with rubber tires. The machine consists of the Fordson tractor power unit, the company's earth boring unit and a capstan winch both

driven by the company's power take-off. The machine will dig at any angle up to 45 deg. and 7 ft. deep. The ordinary hole is 20 in. in diameter, but other augers are available from 4 in. to 24 in. in diameter. It is claimed that the machine will dig in hardpan, shale and frozen ground. The capstan has 2,500 lbs. capacity, and all gears in the boring case operate in a bath of oil. The machine piles the dirt at the edge of the hole convenient for back filling.

Double-Arch Feature on Dragline Bucket Increases Its Durability

A new dragline bucket recently announced by G. H. Williams Co., Erie, Pa., has been designed with a double arch, which, according to the company, eliminates the tendency of the bucket to pull in at the sides in hard digging. The heavy one-piece steel bridge across the top is reinforced by a heavy alloy steel digging lip. An arch above, and one below, takes care of all the pulling-in strains and is claimed to hold the bucket in shape even after the hardest continuous digging. To make the bucket even stronger, the scoop is rolled from a heavy one-piece steel plate which forms both the bottom and sides, with the back flanged in and securely riveted. On the bottom, the scoop is reinforced by heavy flat bars serving also as runners. Standard digging teeth, with reversible manganese steel tips, are riveted to the ends of these bars.

The buckets can be easily adjusted for shallow stripping cuts, for sloping ditches, or for deep digging, on each class of work giving the full advantage of the bucket's entire weight. The dumping chains have been fully pro-



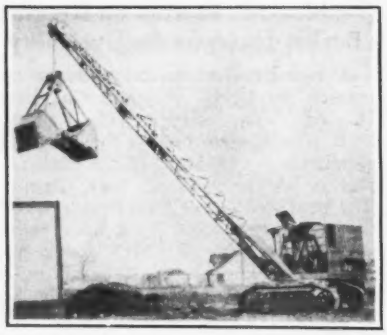
tected against fouling. Another feature is that the trunnions have their closed side toward the work so that they will not clog with material.

Three Crane Models Announced in 6, 10 and 12-Ton Sizes

Three new models of cranes, all of which are convertible into shovels, draglines, ditchers and skimmers, have recently been brought out by the Orton Crane & Shovel Company, Chicago.

The model "A" crane has a capacity of 6 tons, handling a ½-yd. bucket with a 30-ft. boom and having a capacity of ½ yd. as a shovel. The model "G" is rated at 10 tons, or 1 yd. The model "W" is rated at 12 tons, or 1¼ yd. It is claimed that these ratings are conservative because all working parts are made with a liberal factor of safety. Crane booms are of the four-angle, lattice, box-section type, giving strength and rigidity without excessive weight.

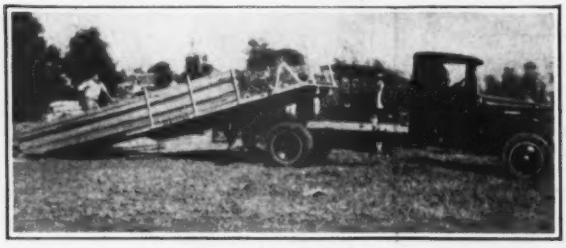
All of these models are arranged for operation by either gasoline engines or electric motors. They are crawler mounted, full-revolving, and have separate clutch shafts for traveling, steering, swinging, hoisting, crowding and booming, so that operations can be performer independently and simultaneously. All-steel cabs are provided.



The accompanying illustration shows a model "G" 10-ton crane with a 1-yd. clamshell bucket.

Special Truck Body Permits Easy Unloading of Lumber

A new piece of equipment known as "The Lumberjack," has recently been developed by the Hughes-Keenan Co., Mansfield, Ohio. This new equipment is a platform body designed for unloading such building materials as lumber, brick and tile. The entire platform body rolls back until the rear end of the load drops easily and smoothly to the ground. As a truck moves away the load rolls off the body on rollers in the body itself, and is deposited in a neat pile.



Materials such as brick are piled on boards placed on the platform first, and the load with the boards is deposited on the ground without being touched by the driver.

Business Notes

GALION IRON WORKS & MFG. CO., Galion, Ohio, has appointed the following distributors: Kiger & Co., Indianapolis, Ind.; Hall-Perry Machinery Co., Butte, Montana; and Herd Equipment Co., Oklahoma City, Oklahoma.

VAN CORTRIGHT MEKEEL, formerly connected with the Taylor-Wharton Iron & Steel Co., of High Bridge, N. J., as special research investigator and sales engineer, has resigned to accept a position as special representative of the Nugent Steel Castings Co., Chicago, Ill.

WHEELING STEEL CORP., Wheeling, W. Va., has purchased the Riverside tube plant of the National Tube Company at Benwood, W. Va. The entire plant, except the coke department, which is operated by the Semet-Solvay Company, was purchased, including 70 acres of land, buildings, equipment, two blast furnaces and their equipment. The plant has been idle for more than two years, and it is stated that parts of it will now be in operation by Feb. 1.

LINK-BELT COMPANY, Chicago, announces the appointment of four vice presidents: George P. Torrence, with headquarters at Indianapolis, in general charge of Indianapolis operations and sales; George L. Morehead, Philadelphia, in charge of eastern operations and sales; Frank B. Caldwell, in charge of the Chicago plant and sales offices tributary thereto; and W. C. Carter, in general charge of production at all plants, with headquarters at Chicago.

REED-PRENTICE CORPORATION, Worcester, Mass., announces that George W. McIntyre has been appointed New York representative. Mr. McIntyre was for many years connected with the Niles-Bement-Pond Company at New York and Chicago.

FAIRBANKS, MORSE & Co., Chicago, have recently acquired complete sales rights to the Price turbine pump manufactured and marketed for many years by the G. W. Price Pump & Engine Company, San Francisco. Activities of the Price organization have been confined largely to California and the Pacific Coast territory so that the new arrangement will now make the pump available in all territories reached by Fairbanks, Morse. The pump is for deep well pumping service and is available in any number of stages, depending upon the working head and the amount of water desired.

INDUSTRIAL EQUIPMENT CORPORATION, with general offices and warehouses at Carnegie (Pittsburgh), Pa., which has recently been organized, has developed a plan claiming to make possible the buying of used machinery and equipment with absolute confidence as to type, condition, quality and price. L. A. Green, formerly of the L. A. Green Railway Equipment Company, will be manager of the new organization.

HENDRICK MANUFACTURING COMPANY, Carbondale, Pa., manufacturers of Mitco interlocked steel grating and other products, announces the opening of a Chicago district office in charge of Lon Sloan.

A. J. BROSSEAU, president, Mack Trucks, Inc., has been appointed chairman of the motor truck committee, National Automobile Chamber of Commerce. Mr. Brosseau has also been elected vice-president of the commercial car division of the Chamber. Mr. Brosseau succeeds in both these offices Windsor T. White, formerly chairman of the board of the White Co.

New Publications

Snow Loaders — GEORGE HARRIS MFG. CO., INC., New York City, has devoted a new catalog, No. 1027, to its snow loading equipment. The catalog, while containing detailed specifications and drawings of its snow loaders, is also devoted to a discussion of the importance of snow removal. Then there are illustrations and descriptive matter covering important details of the snow loader, including its conveyor flights, transmission, crawler mounting, gasoline engine, and discharge chute.

Automatic Sub-stations — WESTINGHOUSE ELECTRIC & MFG. CO., East Pittsburgh, Pa., has published booklet No. 1793, being a 27-page publication describing Westinghouse automatic railway sub-stations. Wiring diagrams showing all apparatus used are included in addition to information on the selection of conversion equipment and switching equipment, and illustrations and descriptions of features of the automatic switchgear and the scheme of operation.

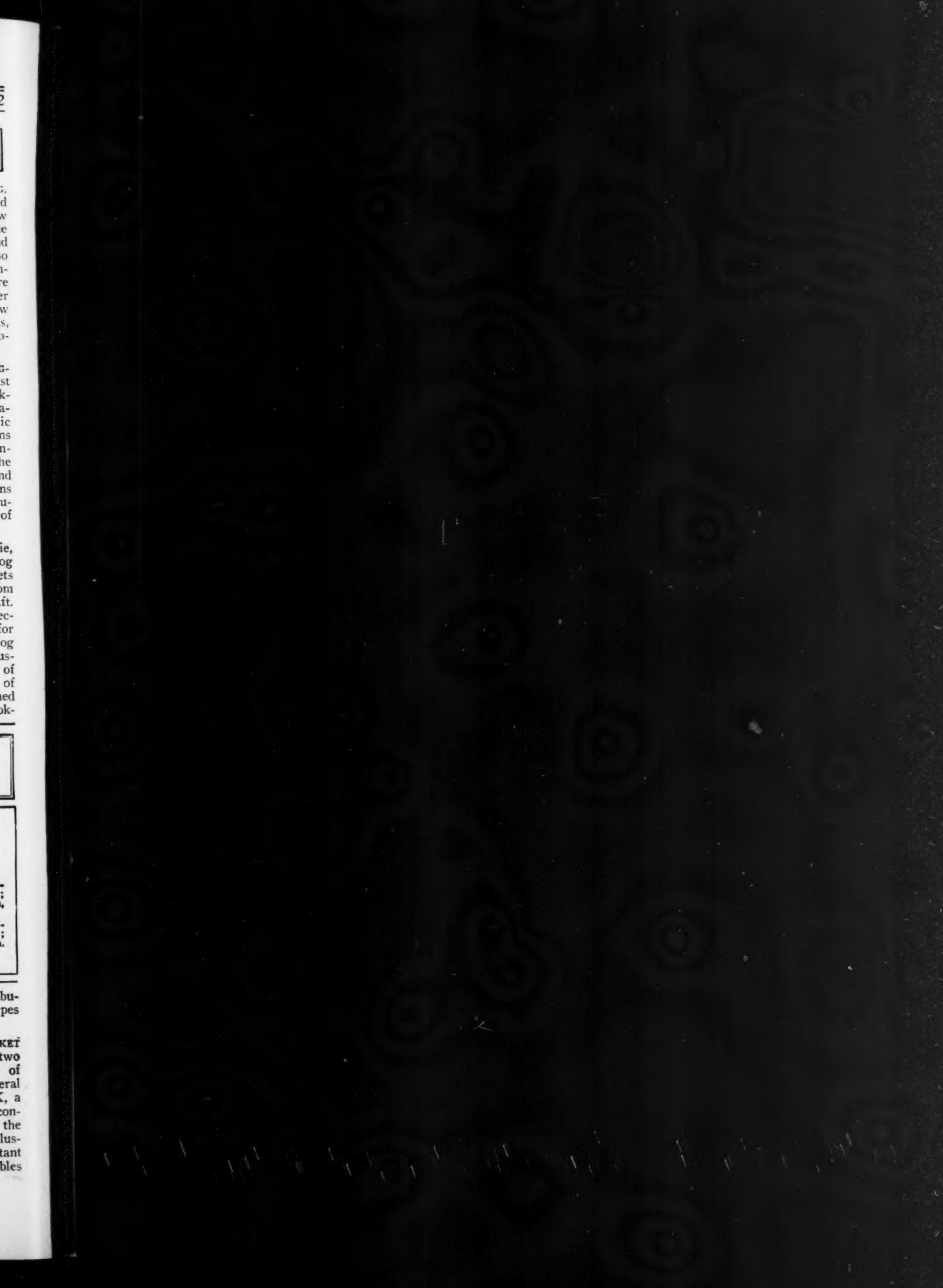
Buckets—G. H. WILLIAMS CO., Erie, Pa., has published a 32-page catalog covering the complete line of buckets that it manufactures. Sizes run from 11 cu.yd. capacity to a small 2 cu.ft. bucket for manhole cleaning. One section is devoted to special buckets for unusual work. A feature of the catalog is that on two facing pages are illustrated and described every type of bucket together with the description of the field of service it has been designed to cover. The remainder of the booklet is devoted to illustrations and tabulated specifications of the various types of buckets.

Clamshell Buckets — OWEN BUCKET CO., Cleveland, Ohio, has published two booklets describing its new types of clamshell buckets, type M, a general purpose digging bucket, and type K, a rehandling bucket. These booklets contain illustrations and descriptions of the various models of each type and illustrate and describe various important details of each shovel. Dimension tables for the shovels are included.

Manufacturers and Trade Associations

Calendar

Annual Meetings

NATIONAL CRUSHED STONE ASSOCIATION, Washington, D. C.; Annual Convention, West Baden, Ind., Jan. 16-19, 1928.

NATIONAL PAVING BRICK MANUFACTURERS ASSN., Chicago; Annual meeting, Chicago, Jan. 25-26, 1928.